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NATIONAL DAM INSPECTION PROGRAM. BOYD KELLER RESERVOIR DAM (NDS--ETC(U)
JUL 78 DACW31-78-C-0044
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LEVEL II

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SUSQUEHANNA RIVER BASIN

BOYD KELLER RESERVOIR DAM

COMMONWEALTH OF PENNSYLVANIA

CLINTON COUNTY

INVENTORY NUMBER NDS 745

PHASE I INSPECTION REPORT

(6) NATIONAL DAM INSPECTION PROGRAM.

Boyd Keller Reservoir Dam (NDS 745), Susquehanna River Basin, Clinton County, Commonwealth of Pennsylvania. Phase I Inspection Report.

(15) DACW31-78-C-0044

Prepared For
DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland

by

BERGER ASSOCIATES, INC.
CONSULTING ENGINEERS
HARRISBURG, PA.

(12) 62p.

(11) 5 JUL 1978

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SB 46

LEVEL II

(1)

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

Name of Dam:	Boyd Keller Reservoir
State and State Number:	Pennsylvania PA. 18-1
County Located:	Clinton
Stream:	McElhattan Creek, Susquehanna River Basin
Date of Inspection:	May 22, 1978

Based on a visual inspection, past performance and available engineering data, the dam and its appurtenances appear to be in good condition. The following recommendations are made:

1. Owner should carefully monitor the volume of leakage discharged from the collector system, and observe any turbidity of the water, and contract for repairs if such need is indicated.

2. Owner should backfill to top of spillway walls and fill the low area on top of embankment.

3. The construction of an access road outside the flood plain is recommended for emergencies.

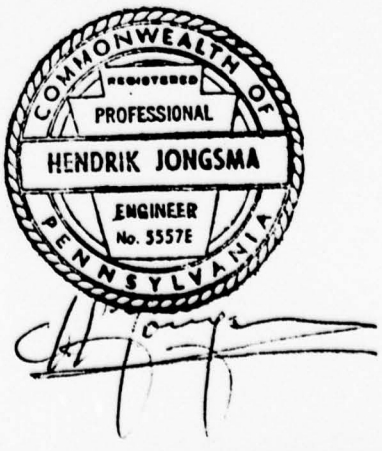
In accordance with the Corps of Engineers' evaluation guidelines, the spillway capacity is inadequate for passing the PMF (Probable Maximum Flood) peak inflow without overtopping the dam. It is, however, capable of passing 66 percent of the PMF peak inflow and, therefore, it is not considered to be seriously inadequate.

A formal surveillance and downstream warning system should be developed to be used during periods of high precipitation.

Submitted by:

BERGER ASSOCIATES, INC.
HARRISBURG, PENNSYLVANIA
Contract No. DACW31-78-C-0044

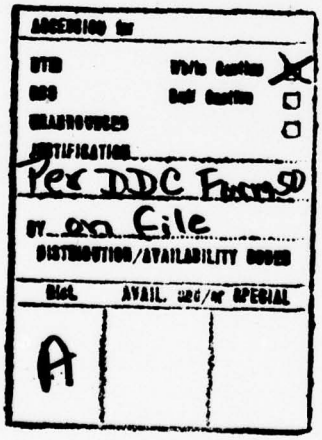
Date: July 5, 1978

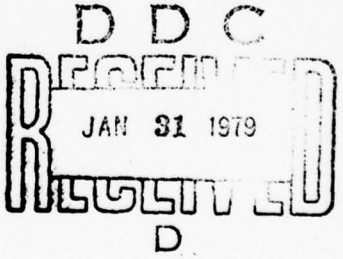


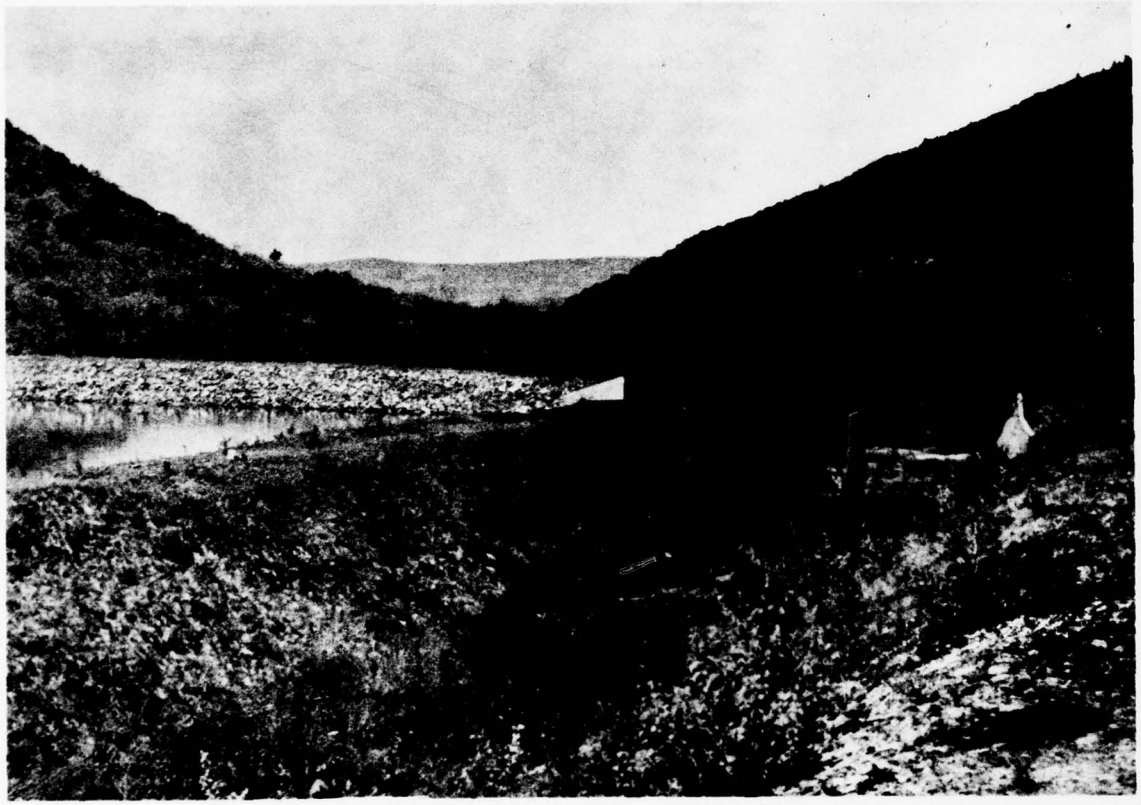
APPROVED BY:

G. K. WITHERS
Colonel. Corps of Engineers
District Engineer

DATE: 20 Jul 78







OVERVIEW

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority

The Dam Inspection Act, Public Law 92-237 authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspections of dams throughout the United States. Phase I Inspection and Report is limited to a review of available data, a visual inspection of the dam site and the basic calculations to determine the hydraulic adequacy of the spillway.

b. Purpose

The purpose is to determine if the dam constitutes a hazard to human life and property.

1.2 DESCRIPTION OF PROJECT

a. Dam and Appurtenances

The Boyd Keller Reservoir Dam, formerly known as McElhattan Dam, is a zoned embankment fill. The length of the crest is 590 feet and the height of the dam from bottom creek bed to top of dam is 53 feet (Appendix D, Plate VI). The as-built drawings indicate the top dam elevation at 919 U.S.G.S. datum. A spillway has been constructed in the west (right) abutment with a crest elevation of 908. The weir length is 130 feet. A by-pass channel has been constructed from the upstream end of the reservoir to the spillway and turbid water can be discharged directly over the spillway by closing two 24-inch valves at the upstream end. An intake tower is located at the upstream side of the dam and is accessible by a footbridge. All gate controls are located in this tower. The outlet conduit is a 24 inch diameter pipe. The dam is located 4.5 miles downstream from the Warren H. Ohl Dam, which is also owned by the City of Lock Haven.

b. Location: Wayne Township, Clinton County
U.S. Quadrangle, Loganton, Pa.
Latitude 41°-07.5', Longitude 77°-20.1'
(Appendix D, Plates I and II)

c. Size Classification: Intermediate

d. Hazard Classification: High (See Section 3.1.e)

e. Ownership: Lock Haven City Authority
20 East Church Street
Lock Haven, Pa. 17745

f. Purpose of Dam: Water Supply

g. Design and Construction History

The dam was designed by Hill and Hill Engineers, North East, Pennsylvania. A permit for construction was granted in March, 1956, and construction was started in April, 1956. Since an existing water supply dam at this location was inadequate to meet the demands of the city, a higher dam, with increased storage was needed. The new spillway was constructed at the right abutment. The existing concrete corewall was utilized in the new embankment fill (Appendix D, Plate VII).

Repairs to the spillway outlet channel were made after completion of the dam to correct excessive erosion at the end of the channel.

h. Normal Operating Procedure

The dam functions as a water supply reservoir for the City of Lock Haven, Pennsylvania. The intake for the water supply is located in the control tower.

1.3 PERTINENT DATA

a. Drainage Area (square miles)	17.3
b. Discharge at Damsite (cubic feet per second) See Appendix B for calculations.	
Maximum known flood at damsite - Estimated from nearby gaging stations.	2,800
Warm water outlet -	None
Outlet conduit at low pool elevation 870.0 -	18
Outlet conduit at normal pool elevation 908.0 -	58
Bypass channel capacity at maximum pool Elev. 919.0	6,000
Spillway capacity at maximum pool Elev. 919.0	16,800
Total discharge capacity at maximum pool Elev. 919.0	22,800

c. Elevation (feet above mean sea level).

Top of Dam -		919
Water supply pool -		908
Spillway crest -		908
Bypass channel sill at entrance to spillway chute -		901.5
Upstream portal invert of outlet tunnel -	about	868.
Downstream portal invert of outlet tunnel -	about	865.
Streambed at centerline of dam -	about	866.
Maximum tailwater -	about	870.

d. Reservoir. (Miles)

Length of maximum pool -	0.4
Length of water-supply pool -	.3

e. Storage (acre feet).

Spillway crest -	278
Top of dam -	546

f. Reservoir Surface (acres)

Top of dam -	30
Spillway crest -	19

g. Dam

The design drawings indicate an embankment with a breast width of 20 feet and a top elevation of 919.0. The upstream slope, which is 3H to 1V is protected by 18-inch riprap from the top of dam to an elevation below the normal water surface of 908.0. The impervious zone of the embankment is the upstream portion of the embankment, ending on a line near the downstream top of dam. The downstream zone is composed of pervious fill on a 2 1/2 H to 1V slope, which is topsoiled and seeded.

The corewall is placed on bedrock, and stops at elevation 879, or forty feet below the top of dam. For a general plan and typical section, see Appendix D, Plates VI through X.

h. Outlet Conduit.

Type - 24-inch concrete pipe which releases water to the stream. There is also an 18-inch cast iron pipe which takes water from the reservoir for domestic use in Lock Haven.

Length - About 485 feet.

Closure - 24-inch gate valve in bottom of control tower about 75 feet upstream from centerline of dam.

Access - foot bridge to control tower.

Regulating facilities - gate valve - manually operated.

i. Spillway and Bypass Channel.

Type - uncontrolled triangular shaped weir. There is also a trapezoidal shaped bypass channel which delivers water to the spillway chute about 25 feet downstream from the weir. Two short 24-inch pipes, with valves, are used to divert water from the bypass channel to the reservoir, when the quality is suitable. At low and medium flows, the bypass channel carrier unneeded water around the reservoir. When the capacity of the bypass channel is exceeded (about 4,000 cfs), the confining embankment will be overtopped and the excess flow will spill into the reservoir.

Length of weir - 130 feet. It has a 24-degree skew.

Crest elevation - 908.0

Upstream channel - rectangular channel with 10 percent slope up to crest. There is a ten-foot wide concrete apron in front of weir.

Downstream channel - There is a 100-foot by 140-foot paved area at the confluence of the flows from the spillway and the bypass channels. From the downstream end of the paved area the chute descends 28 feet in a horizontal distance of about 160 feet to a 50-foot by 80-foot bucket. The entire chute is provided with vertical concrete training walls, about 15 feet high.

j. Regulating Outlets.

Low flow inlet to outlet conduit with invert elevation 867.0 in control tower.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

a. Data Available

1. Hydrology and Hydraulics

A Permit Application Report was prepared by the Pennsylvania Department of Environmental Resources (PennDER) in February 1956, for construction of this dam. The report states the spillway capacity is estimated as 18,353 cfs, equivalent to a runoff of 1060 cfs per square mile of drainage area; and with a possible maximum runoff of 620 cfs per square mile, the spillway will function under a head of 7.7 feet with a freeboard of 3.3 feet.

2. Dam

This same report described the original dam existing at this site, and states that the foundation of the dam was inspected and approved by engineers of the Water Supply Commission of Pennsylvania in 1913 and 1915 and that some grouting was done on the left abutment.

The PennDER files contain sieve analysis of the proposed borrow area for impervious embankment fill and standard compaction tests, as well as an internal friction evaluation. These data were presumably used in the design calculations for the dam.

The information for the embankment consists of a general plan and a typical dam section. Locations of test pits are not indicated.

One drawing included with the contract drawings is a detail of the foundation conditions of the core wall constructed in 1912-15. This drawing indicates a portion of the corewall was constructed on "hardpan", since rock was evidently at a grade too low to reach.

3. Appurtenant Structures

The design drawings indicate details of the control tower, conduit and spillway. The spillway drawings were revised in 1956 to construct a bridge spanning the spillway channel.

b. Design Features

1. Embankment

The design drawings indicate that the foundation area of the embankment was to be stripped. An impervious fill was constructed,

utilizing the existing concrete core wall. The downstream portion of the fill is pervious material, with a gravel and rock toe to collect seepage)Appendix D, Plates VI and VII).

2. Appurtenant Structures

The control structure is located upstream of the dam. All walls are of reinforced concrete and access ladders and platforms provide access to different levels. The sluice gate and water intake valve stands are enclosed in a masonry building with a cast-in-place concrete roof.

An existing conduit housing an 18-inch water supply pipe and a 24-inch waste line was utilized in the new construction. These existing lines terminate in the control building, and were extended upstream by new construction. The 24" waste line terminates approximately 100 feet downstream from the dam in the creek channel, with no energy dissipation.

The spillway weir is triangular in cross section and has a 40 pound rail embedded in concrete at the crest (Appendix D, Plates IX and X). The spillway approach and outlet channels are rectangylar with concrete paving, 12" thick and cantilever walls, varying from 10 feet to 21 feet in height. The chute varies from 130 feet wide at the spillway to 50 feet wide at the lower end at the stilling basin.

A section of the spillway walls have been eliminated to admit a reservoir by-pass channel, which starts 1500 feet upstream from the dam, runs along the right side of the reservoir, and ends in the spillway outlet channel. The by-pass channel is trapezoidal in cross section, with side sloping 1 1/2H to 1V. The channel is excavated in earth, and riprapped for a distance of 50 feet upstream from the spillway. A dike, varying in height from a few feet below the top of the dam to one foot above the top of the dam at the spillway, was constructed on the reservoir side of the by-pass channel (Appendix D, Plate VI). Water may be diverted from the creek channel into the reservoir through two gated 24-inch pipes. During periods of high water, when muddy water flows, the gates are closed, and all the muddy water is diverted from the reservoir. Should flows exceed the channel capacity, water will spill over the low portion of the dike and pass over the spillway.

2.2 CONSTRUCTION

The general appearance of the dam indicates that construction was performed in accordance with the design drawings. Construction data available for review include the original contract drawings and monthly progress reports.

2.3 OPERATION

The purpose of the dam is to supply domestic drinking water. Formal records of operation were not available for review.

2.4 EVALUATION

a. Availability

A full set of design drawings and specifications are available in the files of PennDER. Design criteria and design analysis are not available.

b. Adequacy

1. Hydraulics and Hydrology

Design criteria and analysis are not in the files. The permit application report states that the design Q was 620 cfs per square mile of drainage area (17.3) or equal to 10,700 cfs, and the spillway will discharge this volume with a freeboard of 3.3 feet.

2. Embankment

The embankment design is considered to be adequate.

3. Appurtenant Structures

Design criteria and analysis are not available in the files of PennDER. The design drawings show pertinent construction details and sufficient information is available on the drawings to review and evaluate the structural adequacy.

c. Operating Records

No formal records are available. The city engineer stated no major problems have occurred since construction was completed.

d. Post Construction Changes

The only reported post construction has been the installation of drains and a collection system to eliminate a downstream wet condition. Seepage is discharging from this collector, but the water is clear, showing no movement of fines.

Erosion repair of the spillway outlet channel downstream from the stilling basin has also been performed by placement of additional riprap protection.

e. Seismic Stability

The dam is located in Seismic Zone 1 and it is considered that the static stability with normal safety factors is sufficient to withstand minor earthquake induced dynamic forces. No calculations or studies have been made to confirm this.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General

The general appearance of the dam is reasonably good. According to discussions with the engineers, a regular maintenance program is maintained. The visual checklist is in Appendix A of this report. Photographs made during the inspection are reproduced in Appendix D, Plates III, IV and V.

b. Dam

The upstream embankment slope is covered with riprap to an elevation eight feet below normal water level and appears stable. No failures or unusual conditions were noted. The downstream slope is seeded and in good condition. One low area was noted near the left abutment at the top of dam, but the cause could not be determined. The top of the backfill adjacent to the spillway walls is approximately one foot below the top of wall and could cause an early overtopping of the dam. Drains and a collection system had been installed to eliminate a wet condition below the dam. The dark color green vegetation indicated where these drains had been installed. The collector is discharging in a ditch along the access road. The effluent was clear and no movement of fines was detected. No other seepage was detected at the site.

c. Appurtenant Structures

The intake tower and footbridge are in good condition. The gates are operated to control the water intake, and are regularly maintained.

The spillway by-pass channel, and stilling basins are in good condition, and operate satisfactorily.

d. Reservoir

The reservoir area is clear and well maintained. The banks do not indicate any special erosion problems. The approach to the weir is clear and contains no obstructions. Approximately 4.5 miles upstream is the Warren H. Ohl Dam which is also owned by the City of Lock Haven.

e. Downstream Channel

The channel beyond the stilling basin is a typical mountain stream with heavy growth close to the stream. There are two buildings

located within one mile of the dam. Approximately 2.5 miles downstream of the dam is Youngdale, Pennsylvania, with a population of about 150. Several of the homes are located in the flood plain and the expected loss of life in case of a dam failure would be more than a few. A hazard category of "High" for the Boyd Keller Reservoir Dam is appropriate.

3.2 EVALUATION

The observed condition of the facility was good. The points of concern are:

a. Low area at the top of dam. The low area should be filled to proper grade and be carefully observed to determine if additional loss of material occurs.

b. Backfill should be placed adjacent to the spillway walls, to the top of walls on both sides of the channel, to gain the protection of the full height of the dam.

c. The installation of drains below the toe of dam and near the left abutment indicate that seepage is occurring. The quantity of seepage is not monitored.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

An interview with Mr. Richard Marcinkevage, City Engineer, indicated that during flood stages, access to the dam is not readily available. The roadway to the structure is flooded, and employees do not attempt to observe conditions.

4.2 MAINTENANCE OF DAM

The dam embankment, by pass channel, and outlet channel were being cleared of all unsuitable vegetation. This program is initiated when required, to control plant growth.

4.3 MAINTENANCE OF OPERATING FACILITIES

All gates are operated and oiled on a regular schedule to insure operable conditions.

4.4 WARNING SYSTEM

There is no formal warning system in effect. Measurements are not made of the pool elevation during high discharges, and no staff gauge is available.

4.5 EVALUATION

The general operational procedures are satisfactory. No formal warning system has been established, and the facilities are not patrolled during flood periods.

SECTION 5 - HYDROLOGY/HYDRAULICS

5.1 EVALUATION OF FEATURES

a. Design Data

The hydrologic and hydraulic analysis available from PennDER for Boyd R. Keller Dam was not very extensive. No area-capacity curve, frequency curve, unit hydrograph, design storm, design flood hydrograph, nor flood routings were submitted by the designer to PennDER.

b. Experience Data

The operators of this dam do not keep any records of pool stage or flood discharge. The Water Superintendent recalls that the June 1972 flood was the greatest that has been experienced at the dam. He recalls that the two highway bridges in Youngdale were destroyed by that flood. Youngdale is about 2.5 miles downstream from the dam.

c. Visual Observations

On the date of the inspection, no conditions were observed that would indicate that the appurtenant structures of the dam could not operate satisfactorily during a flood event, until the dam is overtopped.

d. Overtopping Potential

For hydraulic calculations, see Appendix B of this report.

Calculations taking into account the spillway and storage capacities of both Warren H. Ohl and Boyd R. Keller dams and reservoirs indicate that both dams would be overtopped by a Probable Maximum Flood (PMF).

Similar calculations for 1/2 PMF indicate that both dams have sufficient spillway capacity to pass such a flood without any adjustment for storage.

e. Spillway Adequacy

Boyd R. Keller Dam and Reservoir has a storage capacity of 546 acre-feet and a height of 53 feet. These dimensions indicate a size classification of "Intermediate".

In Section 3.1.e it was concluded that the hazard classification for this dam should be "High".

The above two classifications indicate a Spillway Design Flood (SDF) of PMF. Since the total of spillway and bypass channel capacity for this reservoir is 23,000 cfs or 66 percent of PMF peak inflow, the flood discharge facilities are considered to be inadequate, but not seriously inadequate.

Warren H. Ohl Dam, which is 4.5 miles upstream has a spillway capacity of $\frac{5,300 \text{ cfs}}{3.17 \text{ Sq.Mi.}}$ = 1,670 cfs per square mile and Boyd R. Keller Dam has a spillway plus bypass capacity of $\frac{22,800 \text{ cfs}}{17.3 \text{ Sq.Mi.}}$ = 1,320 cfs per square mile.

This indicates that they are well matched, and it is difficult to determine which dam would be overtopped first by storm runoff.

It should be noted that if Warren H. Ohl Dam were to fail suddenly for any reason, at a time when it was full to spillway level (1,700 acre-feet) the resulting flood wave would have more than enough water to overtop Boyd R. Keller Dam even if it were empty. Boyd R. Keller Dam Reservoir has a total capacity of only 546 acre-feet.

The hydrologic analysis for this investigation was based upon existing conditions of the watershed. The effects of future development were not considered.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observation

1. Embankment

There were no observations of undue embankment distress. Considerable seepage does occur along the left abutment and the downstream toe, but the locations and extent of the leakage could not be determined because of the drains and collectors that have been installed below ground. This leakage was observed at the end of the discharge pipe.

Several low areas were noted at the top of the embankment which should be filled.

2. Appurtenant Structures

Visual observations indicate no present stability or stress problems in any of the structures. Previous installation of additional riprap at the end of the spillway stilling basin has apparently corrected erosion at this location.

b. Design and Construction Data

1. Embankment

There are no design criteria for the embankment stability available. The construction drawings indicate good foundations for vertical loads. The small amount of grouting accomplished in 1915 at the right abutment would have little effect on the overall volume of leakage through the foundations. The amount of seepage is relatively constant and there is no turbidity in the water. The present dam was constructed in 1956 and incorporates some of the features of the old dam (See Appendix D, Plate VII). The slopes of the embankment appear to be adequate.

2. Appurtenant Structures

The foundations of the weir and spillway walls cannot be determined, but these structures appear stable and well founded, and are assumed to be on rock.

The intake tower and conduit designs appear to be sufficient for the expected loadings. No anti-seepage fins are indicated on the design drawings.

c. Operating Records

The files do not indicate that the structures have been damaged in past floods with the exception of some erosion in the downstream channel of the spillway.

d. Seismic Stability

This dam is located in Seismic Zone 1 and it is considered that the static stability is sufficient to withstand minor earthquake induces dynamic forces. No studies or calculations have been made to confirm this assumption.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Satety

The visual inspection and operational history indicates that the Boyd Keller Reservoir Dam is in reasonably good condition. However, the visual inspection confirmed considerable leakage occurs in the abutments and downstream from the dam. The amount of leakage does not seem to vary to any marked degree when viewed, and the water is clear. Spring activity and underground seepage could cause a large part of the seepage. No seepage of the embankment was noticed. The spillway will pass 66 percent of the PMF peak inflow and is considered to be inadequate but not seriously inadequate.

b. Adequacy of Information

The available information for this facility is adequate to make a reasonable assessment of the project.

c. Urgency

It is considered that the recommendations made in this section be implemented as soon as possible.

d. Necessity for Additional Studies

Additional studies are not required at this time.

7.2. RECOMMENDATIONS

a. Facilities

In order to assure a continued satisfactory operation of this dam, the following recommendations are made:

1. Owner should carefully monitor the volume of leakage discharged from the collector system, and observe any turbidity of the water, and contract for repairs if such need is indicated.

2. Owner should backfill to top of spillway walls and fill the low area on top of embankment.

b. Operation and Maintenance Procedures

1. Construction of an access roadway outside the flood plain is recommended in case of need to conduct emergency repairs during critical periods.

2. A formal surveillance and downstream warning procedure should be developed to be used during periods of high precipitation.

APPENDIX A

VISUAL INSPECTION

CHECK LIST - DAM INSPECTION PROGRAM

PHASE I - VISUAL INSPECTION REPORT

NAD NO. 745

PA. ID # 18-1 NAME OF DAM Boyd Keller Reservoir HAZARD CATEGORY High

TYPE OF DAM: Earth Fill

LOCATION: Wayne TOWNSHIP Clinton COUNTY, PENNSYLVANIA

INSPECTION DATE 5-22-78 WEATHER Clear TEMPERATURE 75

INSPECTORS: H. Jongsma - G. Errick

A. Bartlett

R. Steacy

NORMAL POOL ELEVATION: 908 AT TIME OF INSPECTION:

BREAST ELEVATION: 919 POOL ELEVATION: 908.1

SPILLWAY ELEVATION: 908 TAILWATER ELEVATION:

MAXIMUM RECORDED POOL ELEVATION:

GENERAL COMMENTS:

Local Contacts:

Richard Marcinkevage, City Engineer, Lock Haven
Stanley Stukel, Water Superintendent, Lock Haven

DAM NO. NAD 745

VISUAL INSPECTION

EMBANKMENT	OBSERVATIONS	REMARKS & RECOMMENDATIONS
A. SURFACE CRACKS	None Noticed.	
B. UNUSUAL MOVEMENT BEYOND TOE	None.	
C. SLOUGHING OR EROSION OF EMBANKMENT OR ABUTMENT SLOPES	None Noticed.	
D. VERTICAL & HORIZONTAL ALIGNMENT OF CREST	Straight and Level except apparent low spots at spillway.	
E. RIPRAP FAILURES	Upstream face riprap in good condition.	
F. JUNCTION EMBANKMENT & ABUTMENT OR SPILLWAY	Slight low spot in Embankment near spillway.	
G. SEEPAGE	None seen.	
H. DRAINS	Toe drains placed 4 years ago per S. Stukel.	
J. GAGES & RECORDER	None seen.	
K. COVER(GROWTH)	Grass & Crown Vetch	

DAM NO. NAD 745

VISUAL INSPECTION

OUTLET WORKS	OBSERVATIONS	REMARKS & RECOMMENDATIONS
A. INTAKE STRUCTURE	Enclosed Building (Locked)	
B. OUTLET STRUCTURE	24 inch R.C.P.	
C. OUTLET CHANNEL	Good	
D. GATES	Locked door, not inspected.	
E. EMERGENCY GATE	24 inch valve.	
F. OPERATION & CONTROL	Good.	
G. BRIDGE (ACCESS)	Steel grating floor & railway in good condition.	

DAM NO. NAD 745

VISUAL INSPECTION

SPILLWAY	OBSERVATIONS	REMARKS & RECOMMENDATIONS
A. APPROACH CHANNEL	25' Bottom by Pass Channel 1:1 earth slopes Being cleared of debris. Some bushes growing in channel.	
B. WEIR: Crest Condition Cracks Deterioration Foundation Abutments	Concrete breast. Appear to be in good condition.	
C. DISCHARGE CHANNEL Lining Cracks Spilling Basin	Vert. Conc. Walls & Slabs a few cracks in bottom slab. Hydraulic Jump at stone sill. Some cattails on west side of basin. Walls in good condition.	
D. BRIDGE & PIERS	Steel Beams with Wooden Planks. Flooring missing on broken in places.	
E. GATES & OPERATION EQUIPMENT	None.	
F. CONTROL & HISTORY	None.	

DAM NO. NAD 745

VISUAL INSPECTION

MISCELLANEOUS	OBSERVATIONS	REMARKS & RECOMMENDATIONS
INSTRUMENTATION Monumentation	None	
Observation Wells	None	
Weirs	None	
Piezometers	None	
Other	Old Deep well at upper end or Reser. not used in 10 yrs.	
RESERVOIR Slopes	West-steep 1:1±trees	
Sedimentation	None apparent, No Algae Problems	
DOWNSTREAM CHANNEL Condition	Good	
Slopes	Wooded	
Approximate Population	Say 100 to 150	
No. Homes	25 - 30	

APPENDIX B

HYDROLOGY/HYDRAULICS

PROJECT Dam Investigation SHEET NO. 1 OF 6

SUBJECT Boyd R. Kellar Dam ID # 745

COMPUTED BY RES DATE 5-26-78 CHECKED BY JJPJr. 6-1-78

Maximum Known flood at damsite

The Water superintendent recalls that the June 1972 flood was the greatest flood that has been experienced at the dam. He recalls that two highway bridges were destroyed in the Youngdale area about 2.5 miles downstream. No pool-stage records were kept for that event.

Discharges at nearby USGS gaging stations for June 23, 1972 were as follows:

Station	Drainage Area	Discharge (cfs)
Blanchard	44.1	4870
English Center	37.7	6260

$\left(\frac{17.3}{44.1}\right)^{0.8} \times 4870 = 2,304$ $\left(\frac{17.3}{37.7}\right)^{0.8} \times 6260 = 3,357$

$\frac{2304+3357}{2} = 2,830$ Use 2,800 cfs

Outlet conduit at low pool elevation 870.0

24" dia. pipe, 485 ft long

$V = \frac{0.590}{n} \times d^{2/3} \times S^{1/2}$

$= \frac{0.590}{0.015} \times (2)^{2/3} \times (0.00825)^{1/2}$

$= 39.33 \times 1.59 \times 0.0908$

$= 5.68$ ft/sec

$Q = VA = 5.68 \times \pi \times (1)^2$

$= 18$ CFS

$n = 0.015$

$d = 2.0$

$S = \frac{870.0 - 866.0}{485}$

$= 0.00825$

King's Handbook 3rd Ed., P 183

Outlet conduit at normal pool elevation 908.0

24" dia. pipe - 485 ft long

$V = \frac{0.590}{n} \times d^{2/3} \times S^{1/2}$

$= \frac{0.590}{0.015} \times (2)^{2/3} \times (0.0866)^{1/2}$

$= 39.33 \times 1.59 \times 0.294$

$= 18.39$ ft/sec

$Q = VA = 18.39 \times \pi \times (1)^2 = 58$ cfs

$n = 0.015$

$d = 2.0$

$S = \frac{908 - 866.0}{485}$

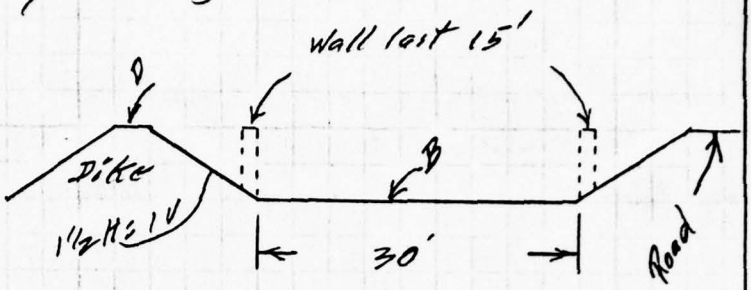
$= 0.0866$

PROJECT Dam Investigation SHEET NO. 1 OF 4

SUBJECT Boyd R. Keller Dam. ID # 745

COMPUTED BY RES DATE 5-30-78 CHECKED BY JJPW 1-30-78

Bypass channel Capacity



Dist. Upstr. from Spillway	B Elev.	D Elev.
0	901.8	916.
60	902	919.
260	903	918.
460	904.	917.
660	905	916
875	906	915
1100	907.	915
1330	908.5	917.

Compute Q for Bypass for reach 460 to 60
Assume water surface slope is equal to invert slope. Assume channel is rectangular and 30 ft wide, and assume n = 0.03

For Water surface at Sta. 460 = 915

Area = 30 × 11 = 330 sq. ft.

$r = \frac{330}{30+11+11} = 6.35$, $S = \frac{904-902}{400} = 0.005$

$V = \frac{1.486}{n} \times (r)^{2/3} \times (S)^{1/2} = \frac{1.486}{0.03} \times (6.35)^{2/3} \times (0.005)^{1/2}$

$= 49.5 \times 3.43 \times 0.0707 = 12.0$ ft/sec

$Q = VA = 12.0 \times 330 = 3,960$ cfs

For Water surface at Sta. 460 = 919 * see below

Area = 30 × 15 = 450 sq. ft.

$r = \frac{450}{30+15+15} = 7.50$, $S = 0.005$

$V = \frac{1.486}{0.03} \times (r)^{2/3} \times (S)^{1/2} = 67.5 \times (7.5)^{2/3} \times (0.005)^{1/2}$

$= 49.5 \times 3.83 \times 0.0707 = 13.4$ ft/sec.

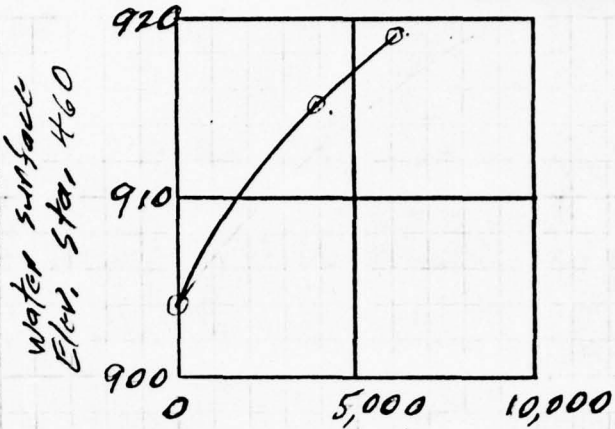
$Q = VA = 13.4 \times 450 = 6,030$ cfs

* At this station, top of dike is at elev. 917, so water will overflow into reservoir. The 6,030 cfs is the flow that will proceed down channel and bypass the weir.

PROJECT Dam Investigation SHEET NO. 3 OF 6

SUBJECT Boyd R. Keller Dam - ID # 745

COMPUTED BY RES DATE 5-30-78 CHECKED BY JJPL 6-1-78

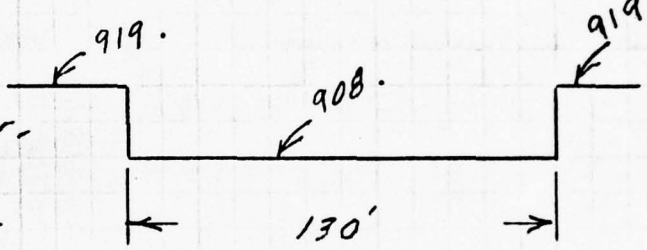


Spillway capacity (free fall)

High-flow angle of approach to spillway 24° from perpendicular.

Cosine = 0.9135

$Q = .9135 \times C \times L \times (H)^{3/2}$

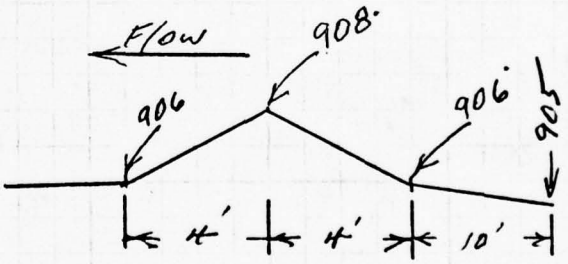


Pool stage 919.

$H = 919 - 908 = 11.$

$Q = .9135 \times 3.87 \times 130 \times (11)^{3/2}$

$= 16,800$ cfs.



C = 3.87

King's Handbook, 6th Ed. Table 5-8

Bypass channel	6,030.
Spillway	16,800
Total	22,800.

Pool stage 916.

$H = 916 - 908 = 8.$

$Q = .9135 \times 3.87 \times 130 \times (8)^{3/2}$

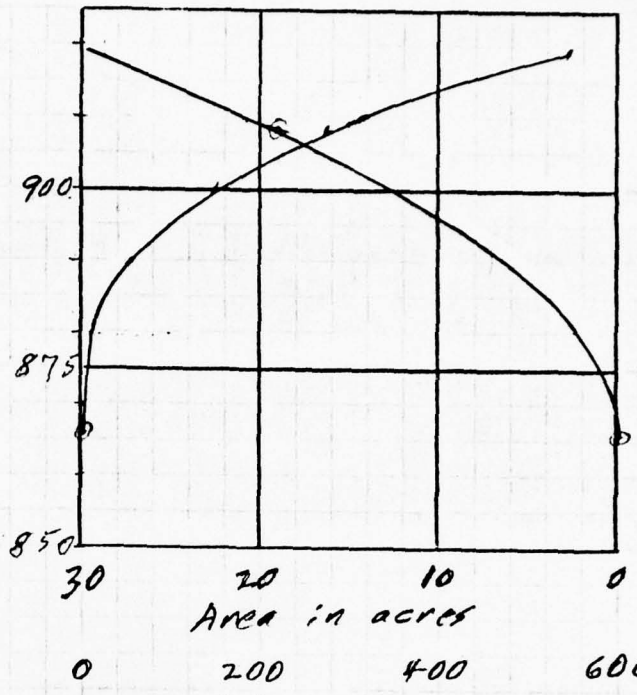
$= 10,400$ cfs.

Bypass Channel	3,960
Spillway	10,400.
Total	14,400 cfs

PROJECT Dam Investigation SHEET NO. 4 OF 6

SUBJECT Boyd R. Keller Dam ID # 745

COMPUTED BY RES DATE 5-31-78 CHECKED BY J.J.P.Jr. 6-1-78



Elev. ft.	Area acres	Av. Area acres	Vol, ac. ft.	Tot, Vol ac. ft.
866	0	0.05	0.2	0
870	0.1	1.15	11.5	0.2
880	2.2	4.30	43.0	11.7
890	6.4	9.60	96.0	54.7
900	12.8	15.90	127.2	150.7
908	19.0	20.00	40.0	277.9
910	21.0	25.30	227.7	317.9
919	29.6			545.6

PMF

	Sq. Mi.
Drainage Area controlled by Ohl Dam and reservoir 4.5 miles upstream	3.17
Drainage Area between dams	14.13
Drainage Area Keller Dam	17.3

PMF values shown below are from relation curves furnished by Balt. Dist., Corps of Eng.

PMF for 17.3 sq. mi. = 2,000 cfs/sq. mi.
= 35,000 cfs.

For Ohl Dam this would be

$$\left(\frac{3.17}{17.3}\right)^{.8} \times 35{,}000 = 9{,}000 \text{ cfs}$$

PROJECT Dam Investigation SHEET NO. 5 OF 6

SUBJECT Boyd R. Keller Dam ID # 14-5

COMPUTED BY RES DATE 6-29-78 CHECKED BY JJP 6-30-78

PMF (cont.)

Ohl Dam Volume of runoff = $\frac{9,000}{10,500} \times 26'' = 22.3''$. (10,500 = Ohl Resv. PMF peak inflow)

$22.3 \times 53.33 \times 3.17 = 3,770$ acre feet.

$\frac{\text{Max Spillway Q}}{\text{Peak Inflow}} = \frac{5,300}{9,000} = 0.59$.

$\frac{\text{Req. Resv Storage}}{\text{Vol. of Inflow}} = 0.41$.

Req. Resv. Storage $= 0.41 \times 3770$
$= 1,550$ ac. ft

See Ohl Dam computations and short cut routing method furnished by Balt. Dist. C. of E.

Available Ohl storage $= 2,520 - 1720 = 800$ ac. ft.

Ohl Dam will be overtopped and can be expected to cause the failure of Boyd R. Keller Dam.

1/2 PMF

1/2 PMF for Keller Dam $= \frac{35,000}{2} = 17,500$ cfs

1/2 PMF for Ohl Dam $= \left(\frac{3.17}{17.3}\right)^{.8} \times 17,500 = 4,500$ cfs

Ohl Dam Vol of Inflow $= \frac{22.3}{2} = 11.2''$.

$= 11.2 \times 53.33 \times 3.17 = 1,890$ ac. ft.

Assume peak outflow = 3,200 cfs. From trial & error computation,

Ohl peak stage = 1669.1

Total storage = 2,247 ac. ft.
spillway crest = 1720 ac. ft.
change in storage = 527 ac. ft.

$\frac{\text{Resv. Storage}}{\text{Vol of Inflow}} = \frac{527}{1890} = 0.28$.

$\frac{\text{Peak outflow}}{\text{Peak Inflow}} = 0.72$.

Peak outflow $= 0.72 \times 4,500 = 3,240$ cfs

Peak outflow for 14.13 sq. mi intervening area

$= \left(\frac{14.13}{17.3}\right)^{.8} \times 17,500 = 14,900$ cfs

SUBJECT Boyd R. Keller Dam ID # 745 SHEET NO. 6

COMPUTED BY RES DATE 6-29-78 CHECKED BY JPV 1-30-78

½ PMF (cont.)

Reduce Okl outflow by 20% to allow for difference in timing.

Okl = 0.8 × 3,240 =	2,600.
Intervening area =	14,900.
½ PMF inflow to Keller	17,500 cfs

½ PMF Vol of inflow to Keller

= 13"

= 53.33 × 13 × 17.3 = 12,000 ac-ft.

For Keller for ½ PMF

Peak inflow = 17,500 cfs

Max spillway capacity = 73,000 cfs (including bypass)

Boyd R. Keller Dam can pass a ½ PMF peak flow

APPENDIX C

GEOLOGIC REPORT

GEOLOGIC REPORT

Bedrock - Dam and Reservoir.

Formation Name: Juniata Formation.

Lithology: Red, find grained sandstone, with some red siltstone and silty shale interbeds. The overlying Tuscarora Formation white quartzite and underlying Bald Eagle Formation, brown sandstone are shown on the map, Fig. 1, but are not involved in the dam or reservoir.

Overburden.

Core borings are not available for this dam. The valley sides are covered with talus and soil derived from the Juniata Formation and the overlying Tuscarora Formation. The drawing of the longitudinal section of the core wall shows that on the west side (left side, looking downstream, but right side on drawing) the overburden was removed and the core wall was founded on bedrock. Near the old stream channel the floor of the trench is labeled "Hardpan". East of the stream channel the floor was in rock to Sta 215L. From that station to the end of the wall the floor of the trench is labeled "gravel" and "red shale". The east valley wall is indicated as "shale" and gravel.

Structure.

The dam is located on the northwest limb of the Nittany Anticline. The beds strike N65°E and dip 10° to 15°NW. The Nittany Anticline is now known to have major thrust faulting on its northwest limb, but no faults are mapped in the vicinity of the dam. No cross faulting is mapped and none is visible on the air photographs. The valley of McElhattan Creek is probably controlled by N5°W to N10°W fractures. Parallel fracture traces were noted on the air photos and are shown on the map, Fig. 1.

Aquifer Characteristics.

The Juniata Formation is composed of essentially impermeable rocks. Ground water movement is almost entirely along bedding planes and fractures. The fractures in the valley of McElhattan Creek are probably a locus of some ground water movement.

Discussion.

The Juniata Formation is resistant to weathering, and has good foundation stability, ref. (1). Some ground water leakage along fractures under the dam is possible. Increased permeability due to ground water movement in the bedrock is highly unlikely due to the insoluble, firmly cemented nature of the rock.

However, not all of the core wall was founded in bedrock. The central area, identified as "hardpan" on the drawing, is on unknown and could be a point of weakness. Also, the east abutment of the core wall may have been founded in overburden, or at least, in partially disintegrated bedrock. If leakage is ever detected at either place, it should be carefully monitored.

Sources of Information.

1. Faill, R. T. and Wells, R. B. (1977). "Bedrock Geology and Mineral Resources of the Linden and Williamsport Quadrangles, Lycoming County, Pa.". Pa. Geological Survey, Atlas 134 ab.

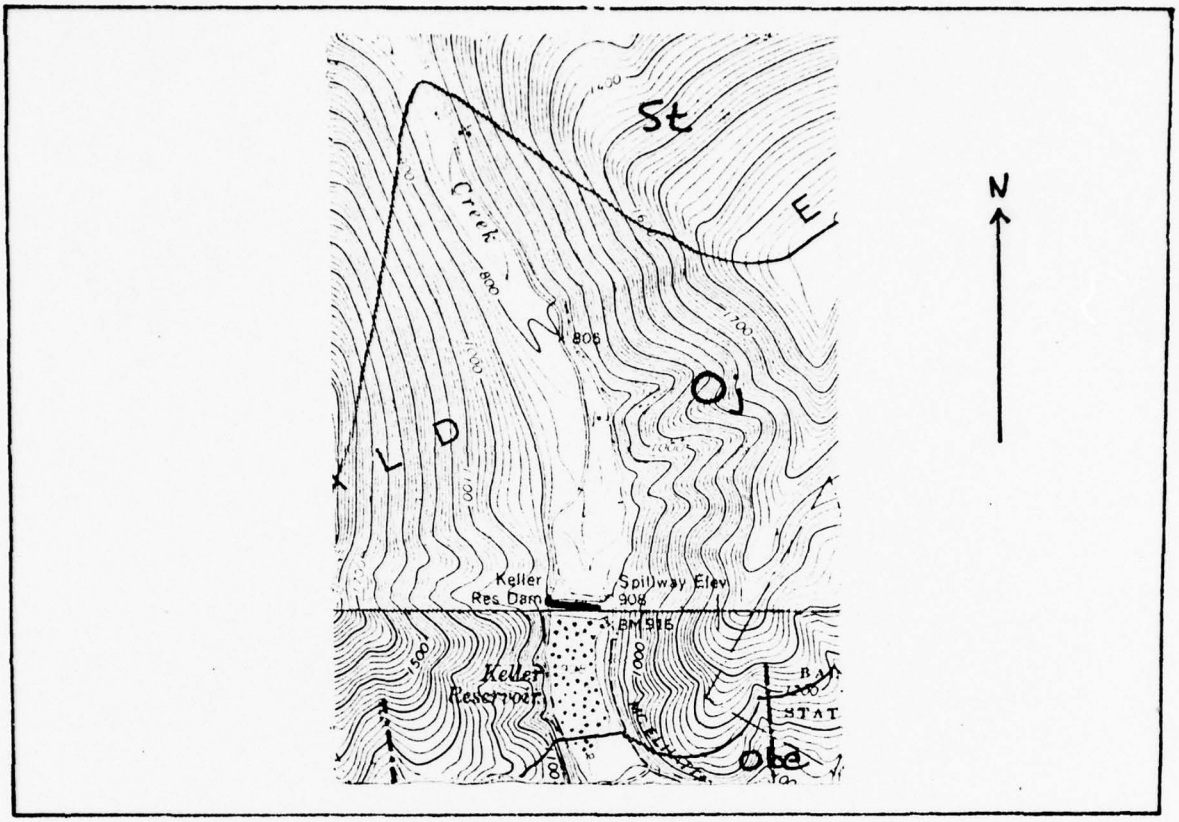
2. Manuscript geologic maps of the Jersey Shore and Loganton Quadrangles, open file (1977), Pa. Geological Survey, Harrisburg, Pa.

3. Air Photographs, scale 1:24,000, dated 1963.

4. Longitudinal section of core wall construction, 1913 - 1915.

5. Photographs taken during construction of the core wall.

GEOLOGIC MAP - Boyd Keller Dam



(Geology from: Manuscript Geologic Map, open file;
Loganton and Jersey Shore Quadrangles;
Pa. Geologic Survey, Harrisburg)

St	Tuscarora Fm.
Oj	Juniata Fm.
Obe	Bald Eagle Fm.
-.-.-.-	air photo fracture trace

SCALE 1 24000

1 0 1 MILE

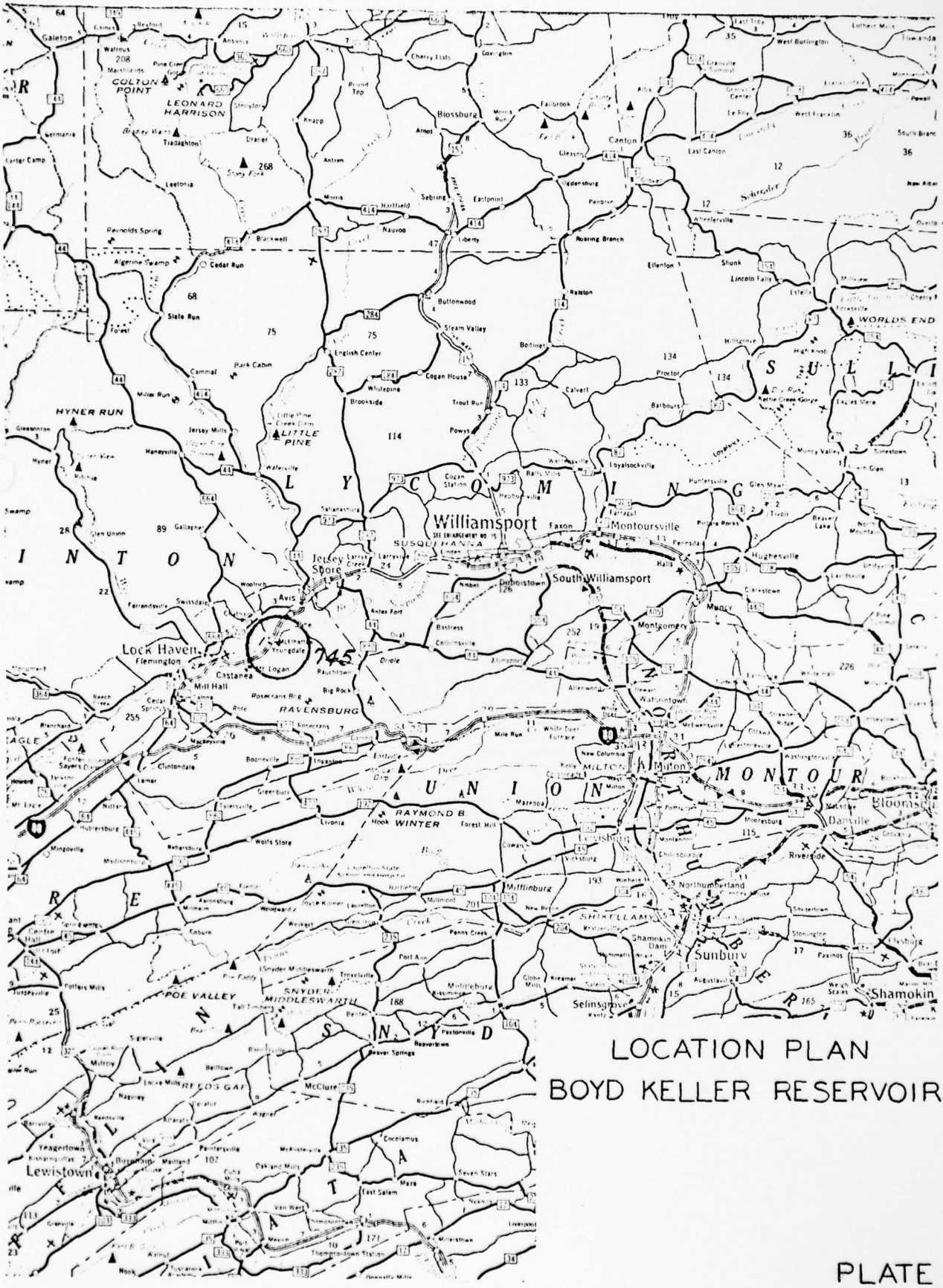
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

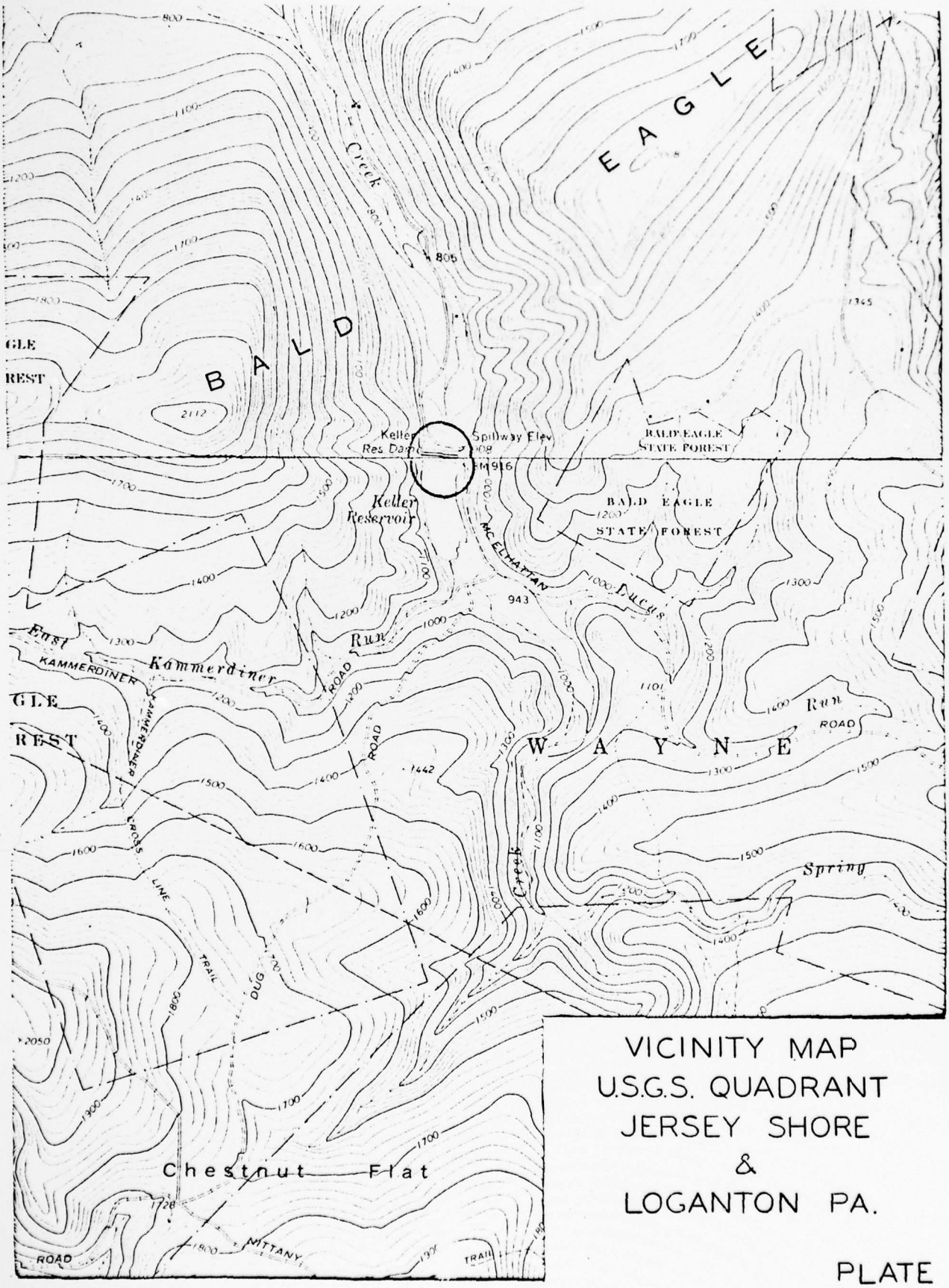
APPENDIX D

LOCATION, PHOTOGRAPHS & DESIGN DRAWINGS



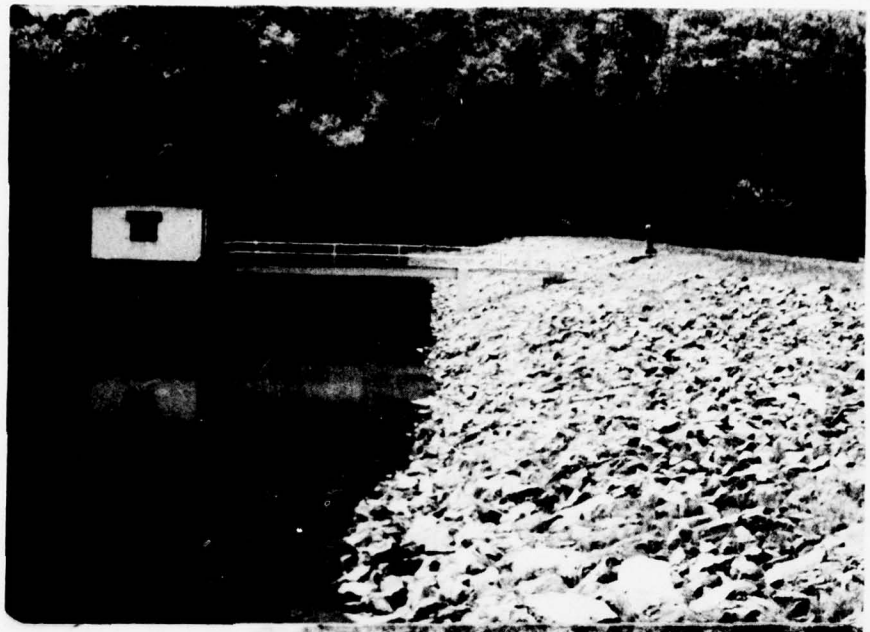
LOCATION PLAN
BOYD KELLER RESERVOIR

PLATE I



VICINITY MAP
U.S.G.S. QUADRANT
JERSEY SHORE
&
LOGANTON PA.

PLATE II

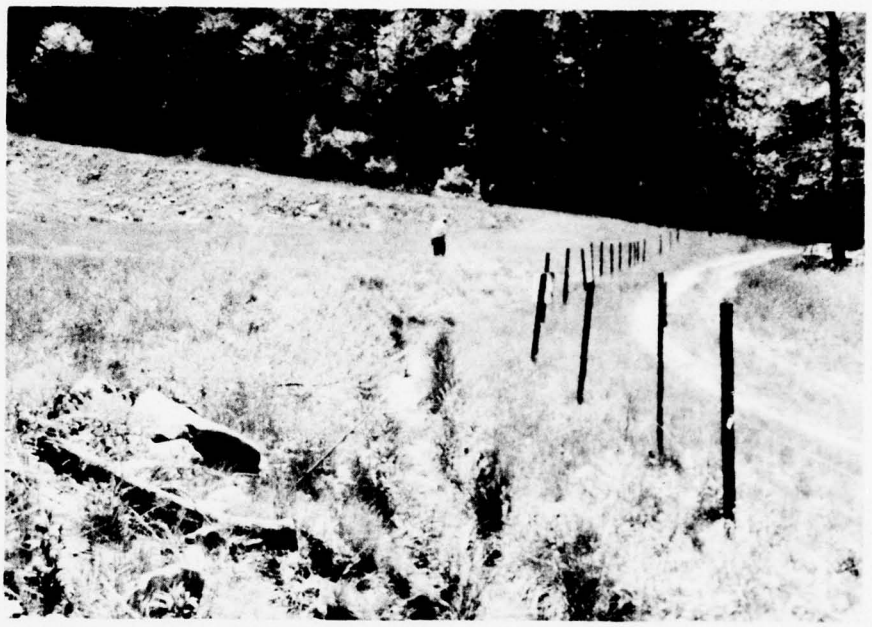


Upstream
Slope

Left Downstream
Embankment

Right Downstream
Embankment

PLATE III

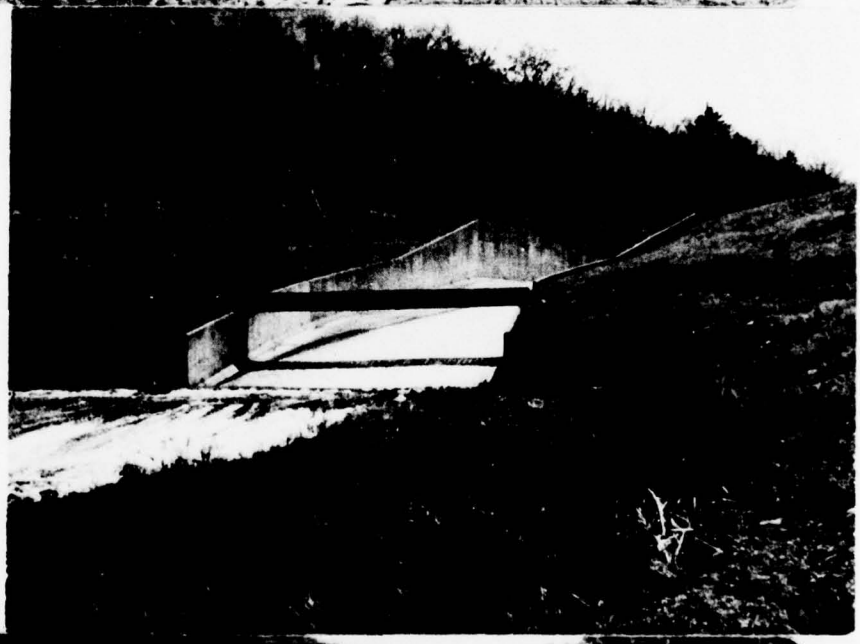


Downstream
Toe

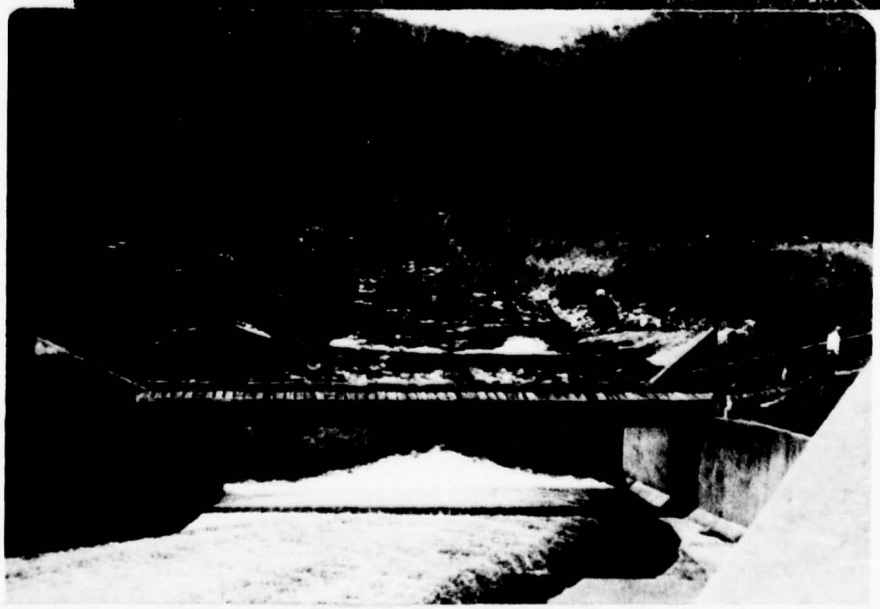
Downstream
Creek

PLATE IV

"Split"
Spillway

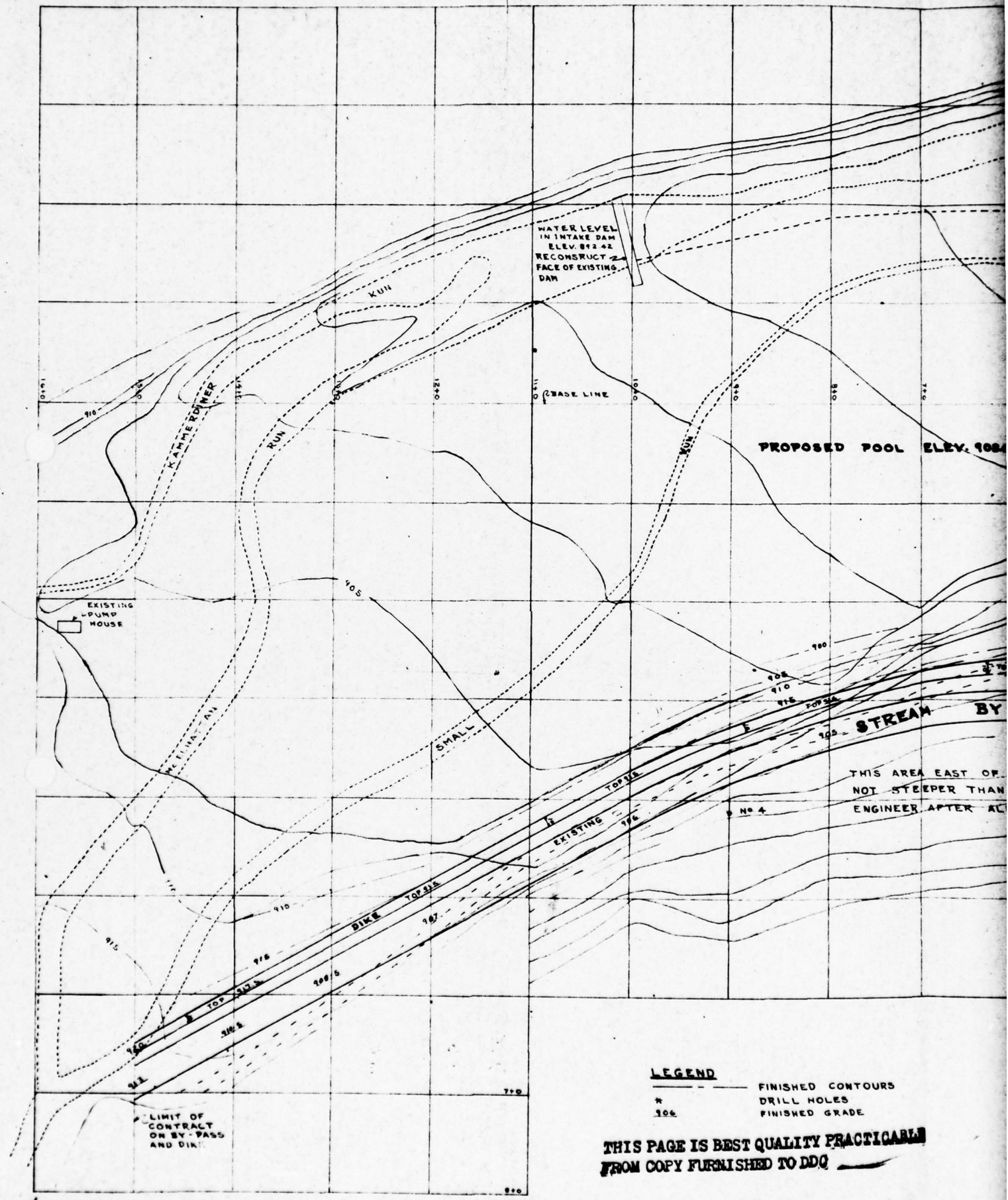


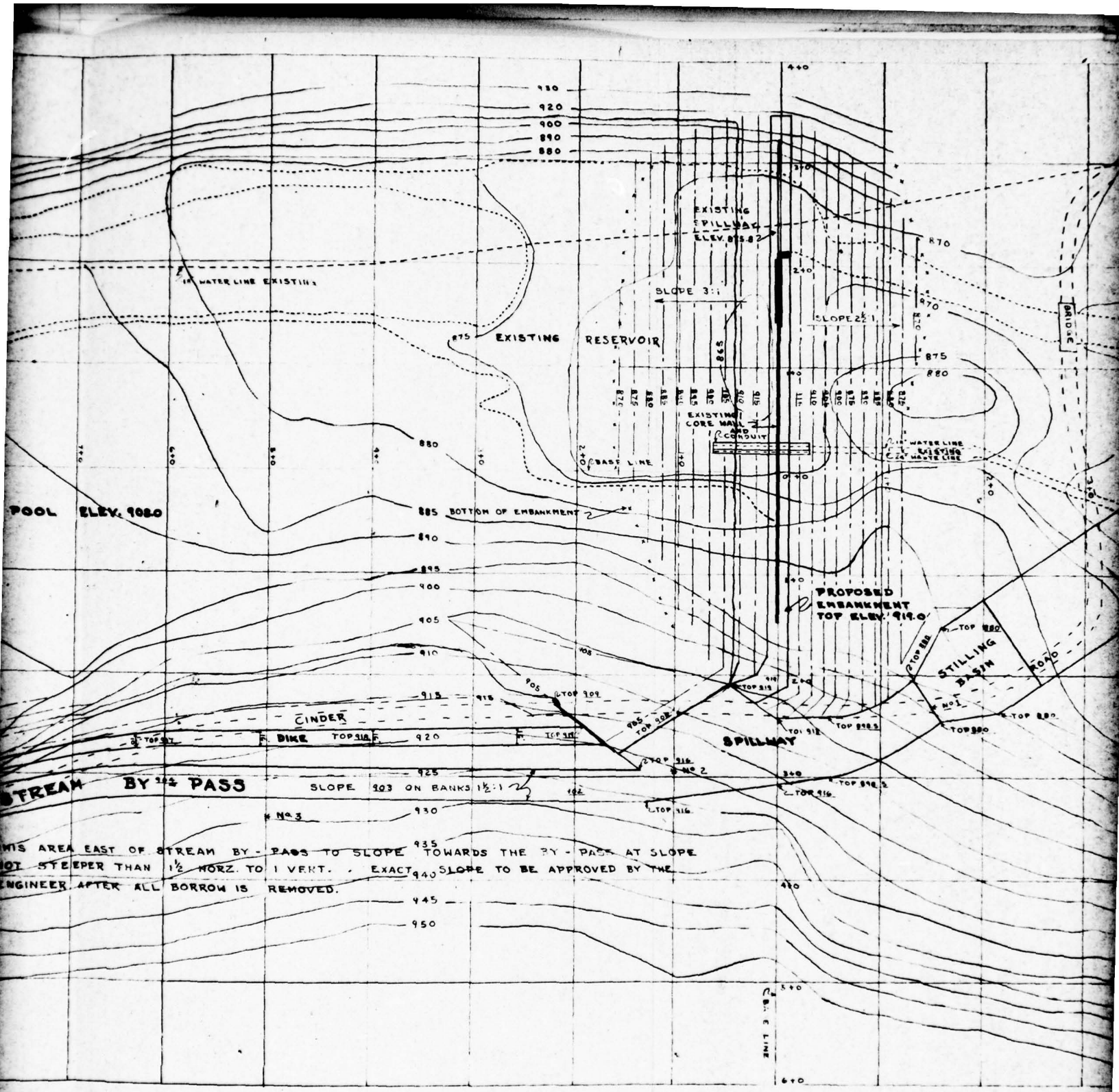
Spillway
Chute



Downstream
Channel

PLATE V

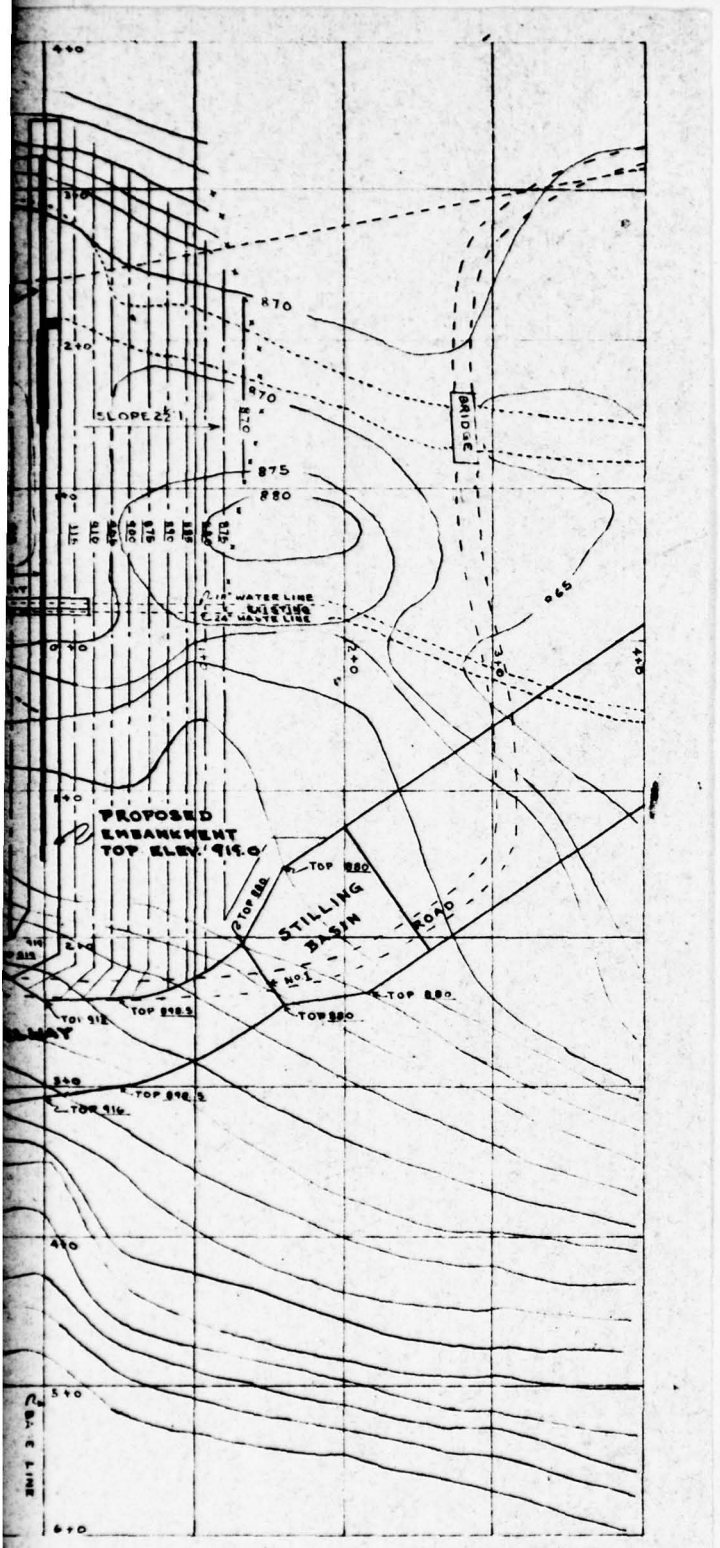




745

PLATE VI

DRAWN BY R.F.M	CONTOUR PL
DATE 12-30-55	RESERVOIR CONS
APPROVED 1-16-56 BY CITY COUNCIL	LOCK HAVEN CITY
APPROVED BY PENNA DEPT HEALTH	
APPROVED BY DEPUTY FORESTRY DEPT	



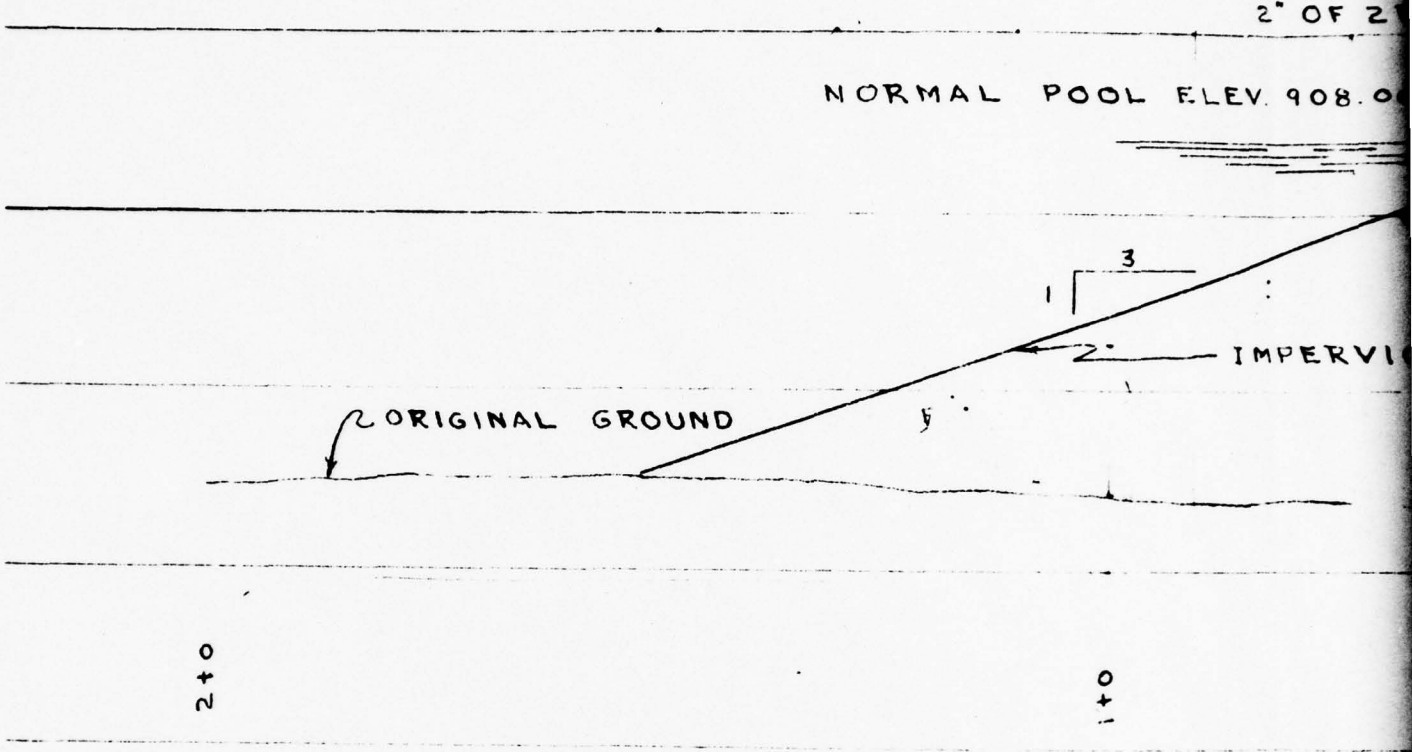
PRACTICABLE

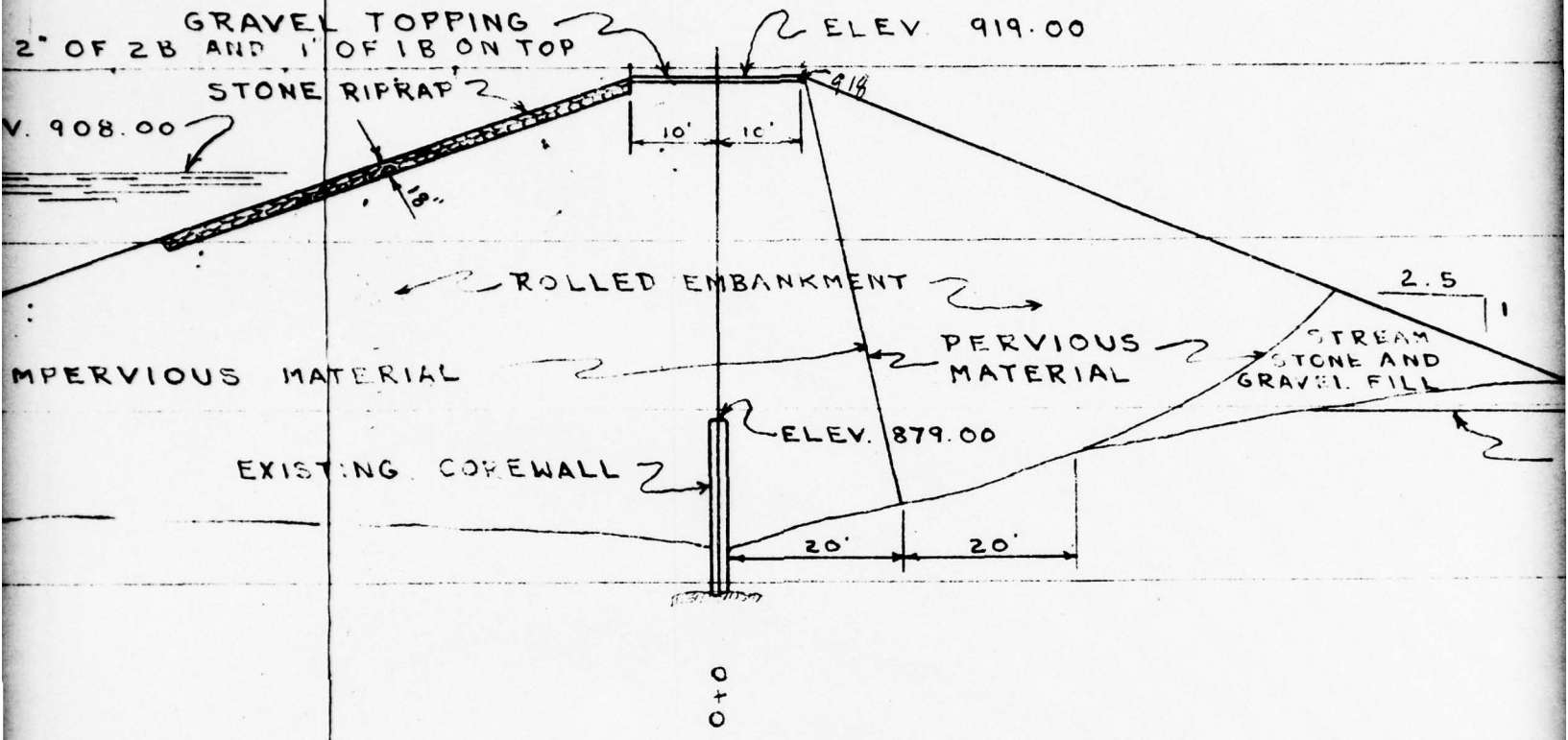
745

PLATE VI

3

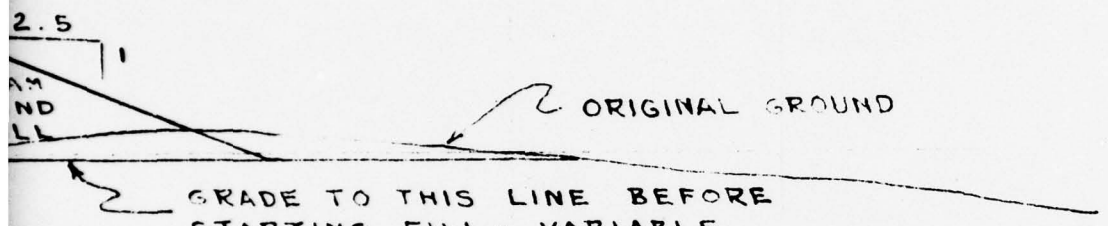
DRAWN BY R.F.M	CONTOUR PLAN
DATE 12-30-55	RESERVOIR CONSTRUCTION
APPROVED 1-16-56 BY COUNCIL	LOCK HAVEN CITY AUTHORITY
APPROVED BY PA. DEPT HEALTH	
APPROVED BY PA. FORESTRY DEPT	





CROSS - SECTION OF BREAST AT STA. 1+0 RIGHT

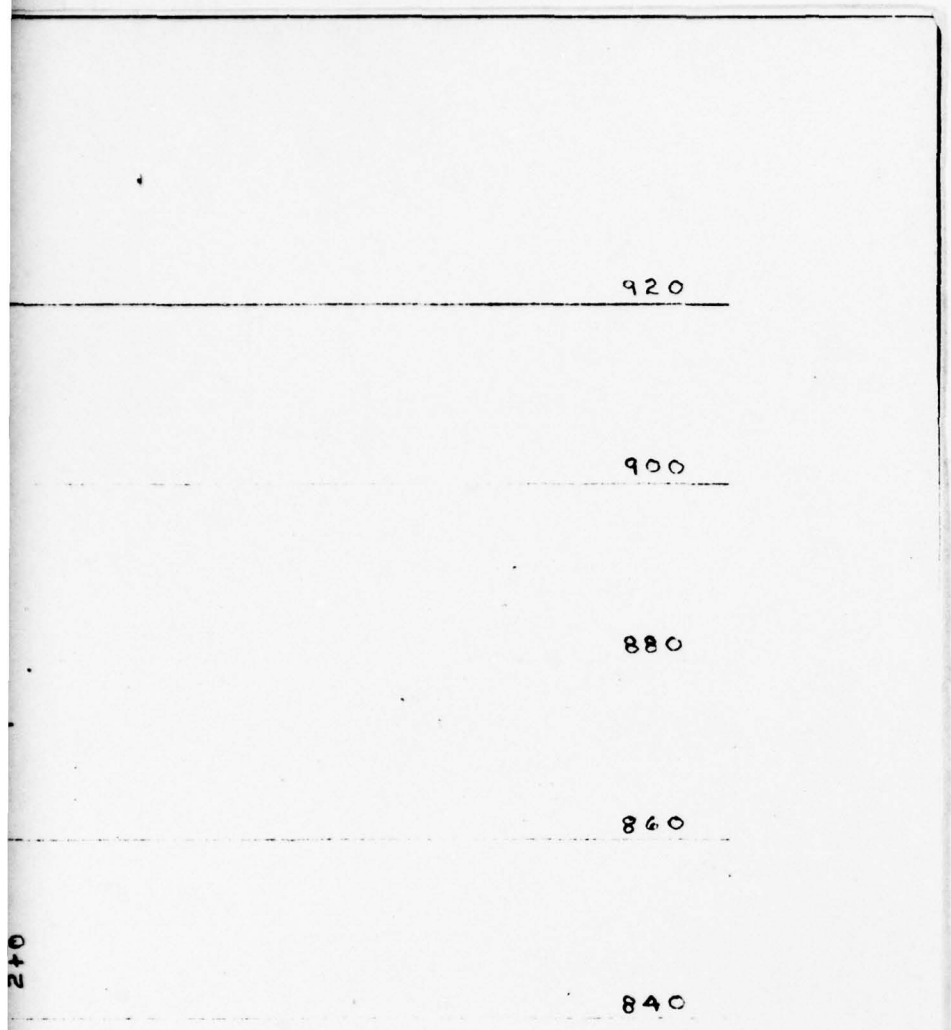
SCALE 1" = 20'



0+

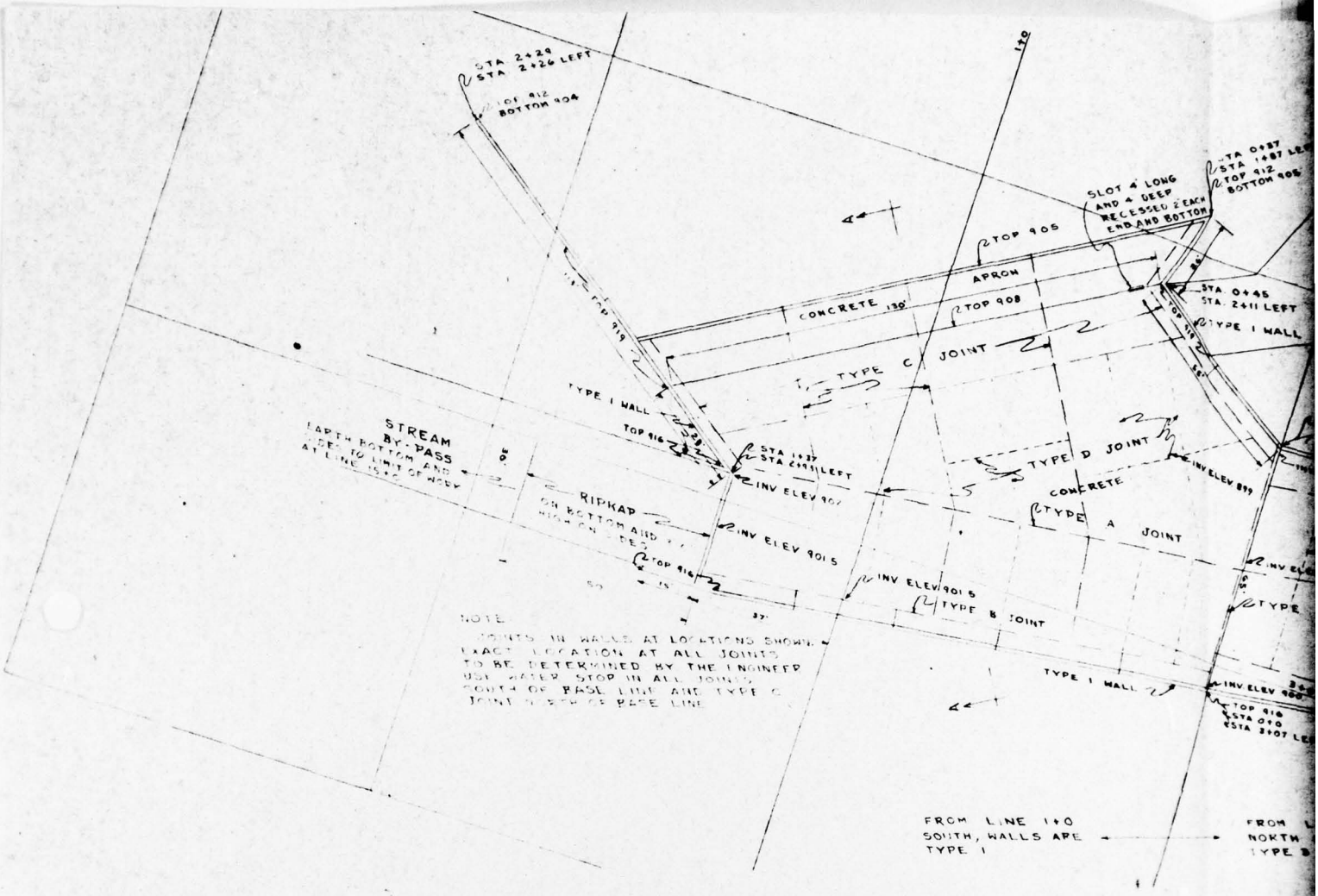
2+0

RIGHT

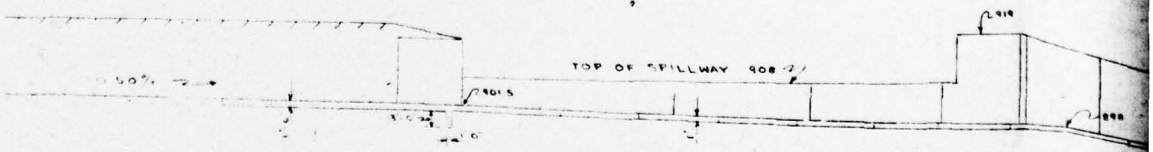


4

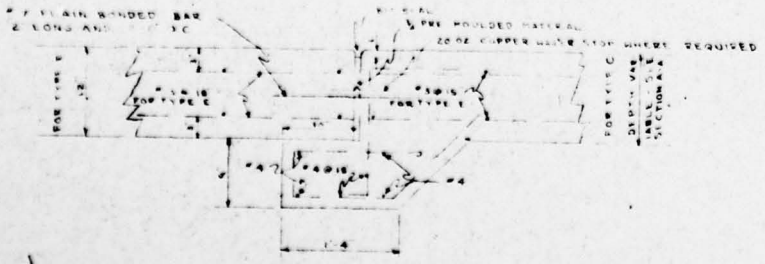
745
PLATE VII



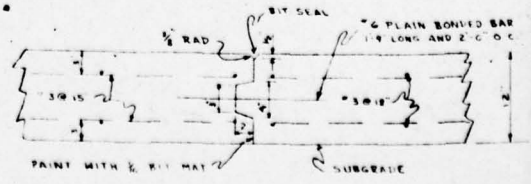
PLAN
SCA



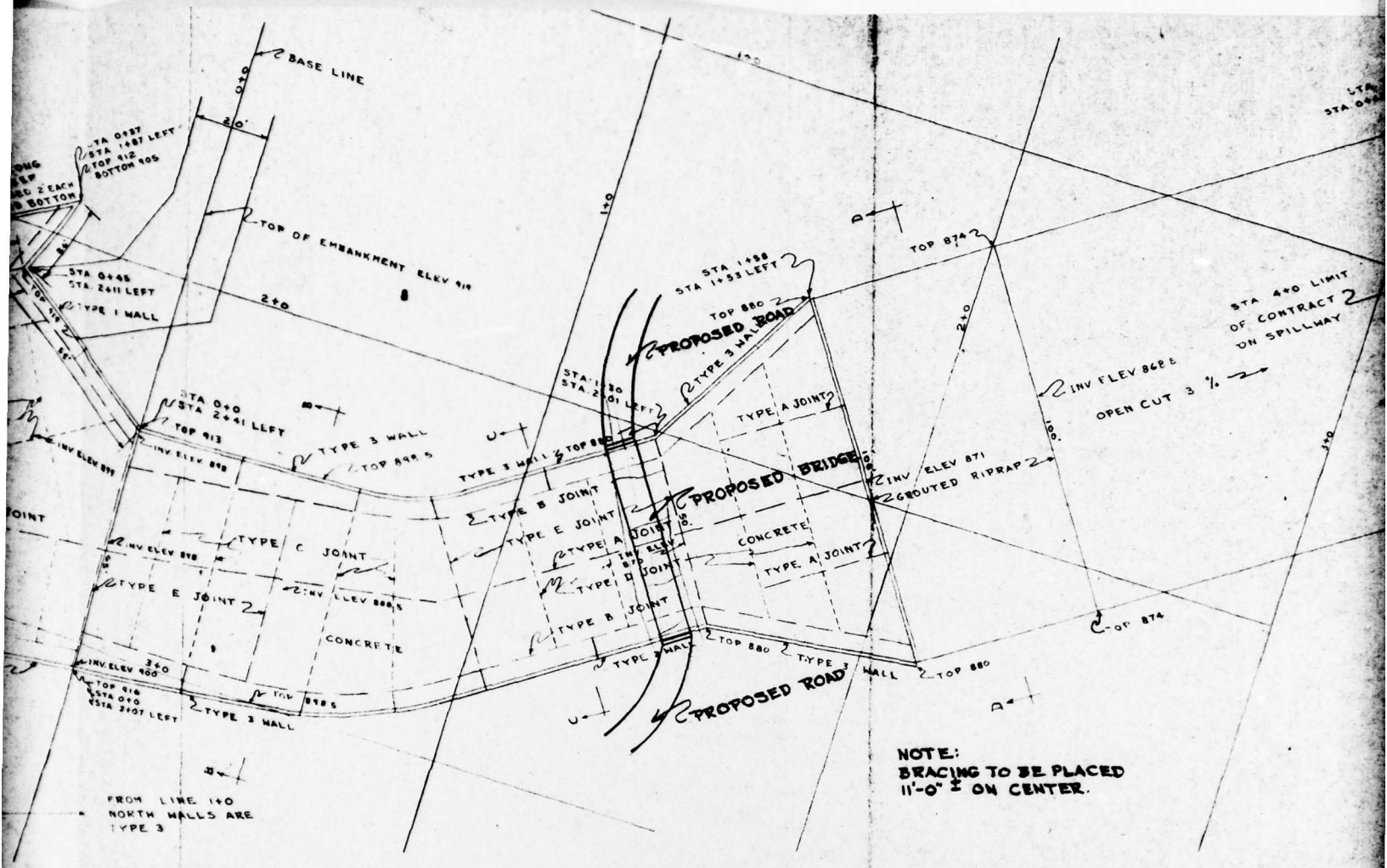
PROFILE
SCALE



TYPE C AND E JOINTS
SCALE 1" = 1'-0"



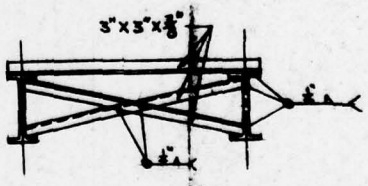
LONGITUDINAL TYPE A JOINT
SCALE 1" = 1'-0"



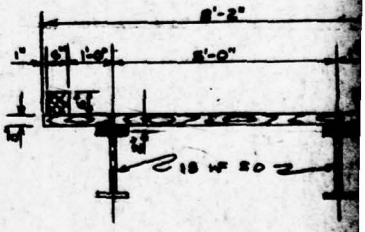
PLAN OF SPILLWAY
SCALE 1" = 20'

NOTE:
BRACING TO BE PLACED 11'-0" ± ON CENTER.

NOTE
SEE SHEET #10 FOR ADDITIONAL DETAILS



TYPICAL SECTION - BRACING
SCALE ½" = 1'-0"



TYPICAL SECTION - WOOD
SCALE ½" = 1'-0"

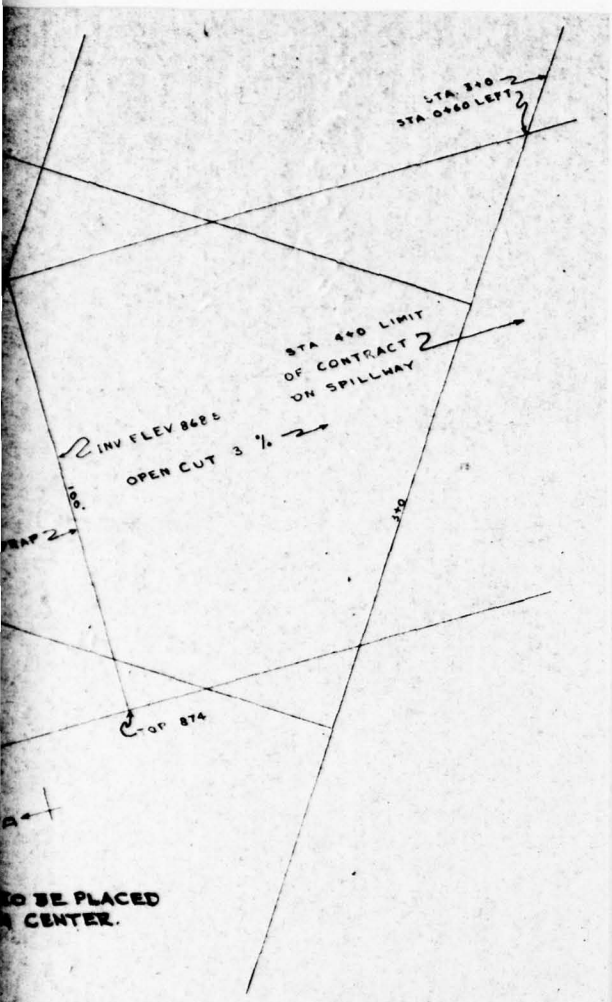
PROFILE OF SPILLWAY
SCALE 1" = 20'

DUMMY - TYPE D JOINT
SCALE 1" = 1'-0"

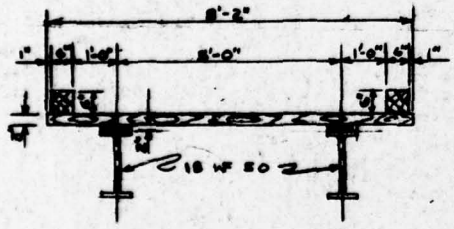
745
PLATE VIII

DRAWN BY R F M	
DATE 12-30-55	
APPROVED 1-16-56 BY CITY COUNCIL	
APPROVED BY PENNA DEPT HEALTH	
APPROVED BY PENNA FORESTRY DEPT	

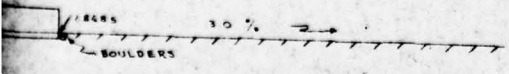
SPILLWAY PLAN AND D
RESERVOIR CONSTR
LOCK HAVEN CITY AU
WARREN H OHL - REGISTERE



TO BE PLACED
CENTER.



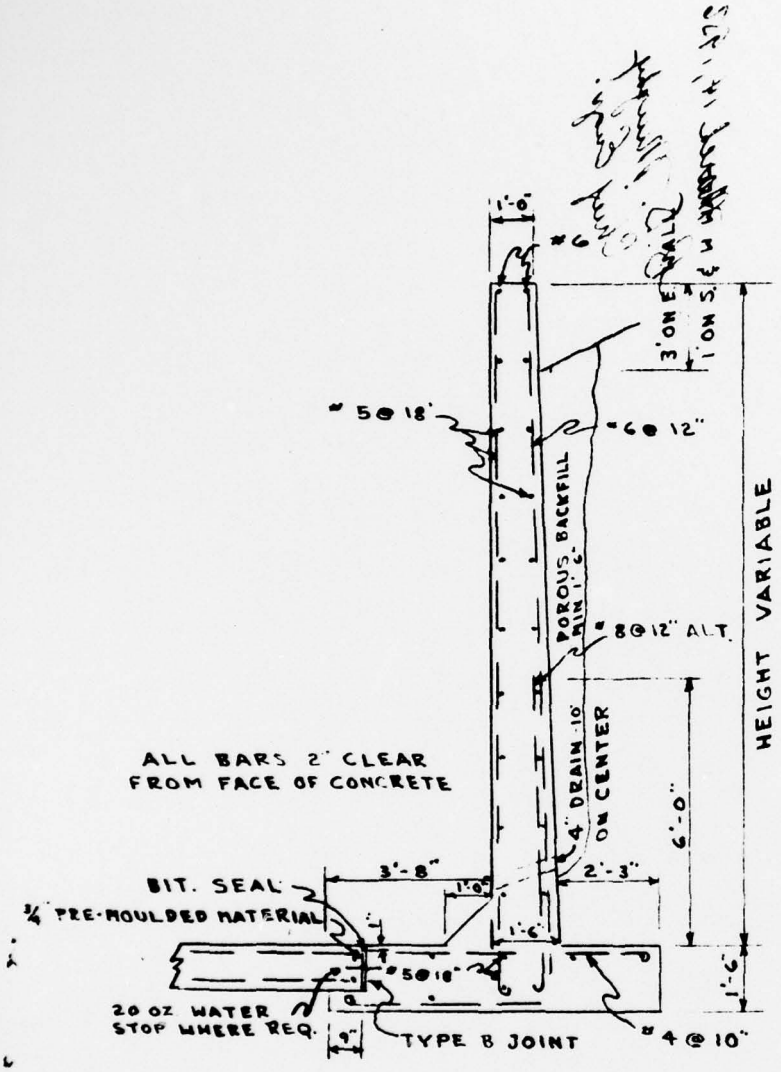
TYPICAL SECTION - WOOD DECK
SCALE ½" = 1'-0"



ITY PRACTICABLE
DOC

745
PLATE VIII
3

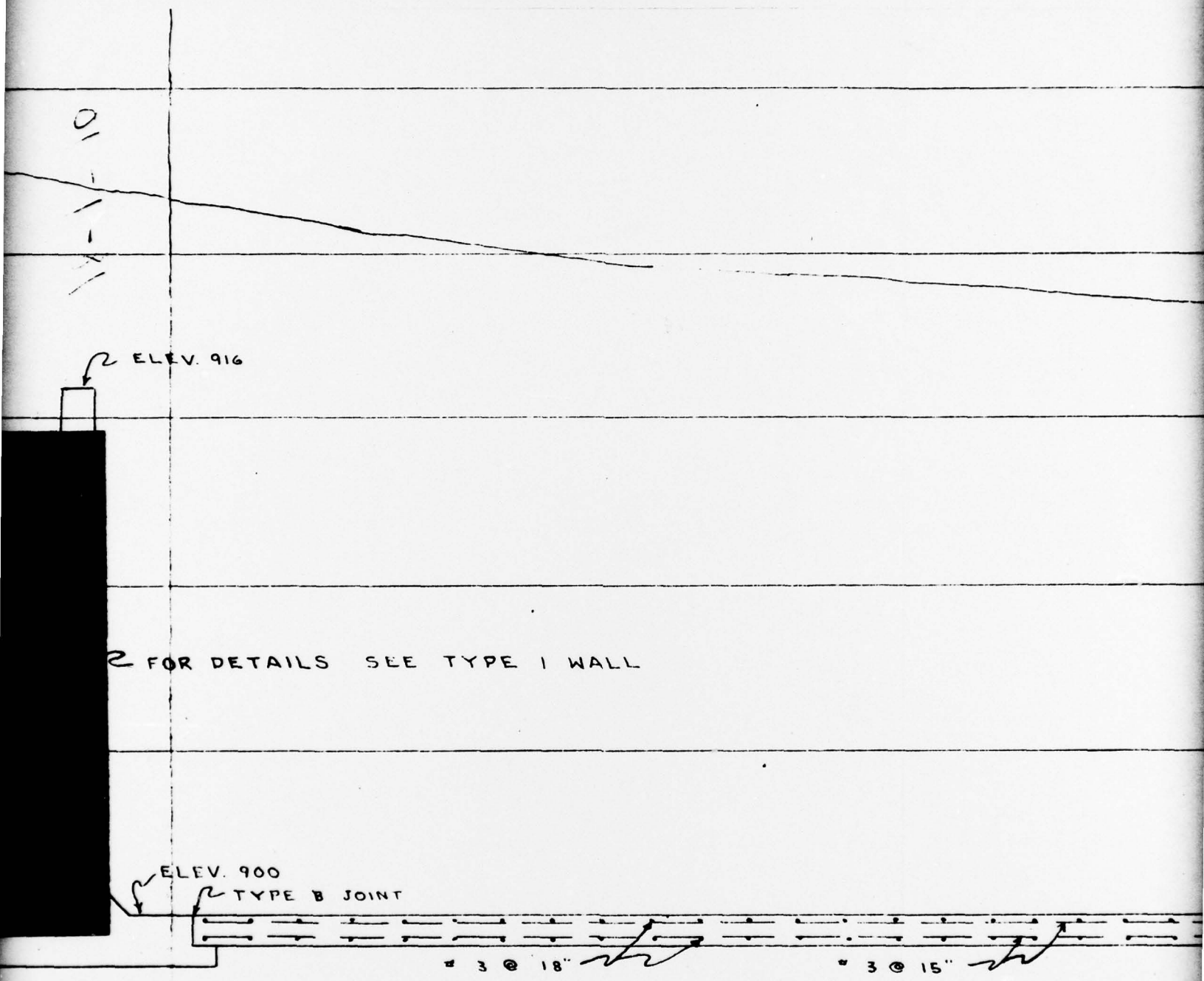
SPILLWAY PLAN AND DETAILS
RESERVOIR CONSTRUCTION
LOCK HAVEN CITY AUTHORITY
WARREN H. OH... REGISTERED ENGINEER



TYPE 1 WALL - TYPE B JOINT

USE ON SPILLWAY SOUTH OF BASE LINE

SCALE 1/4" = 1'-0"

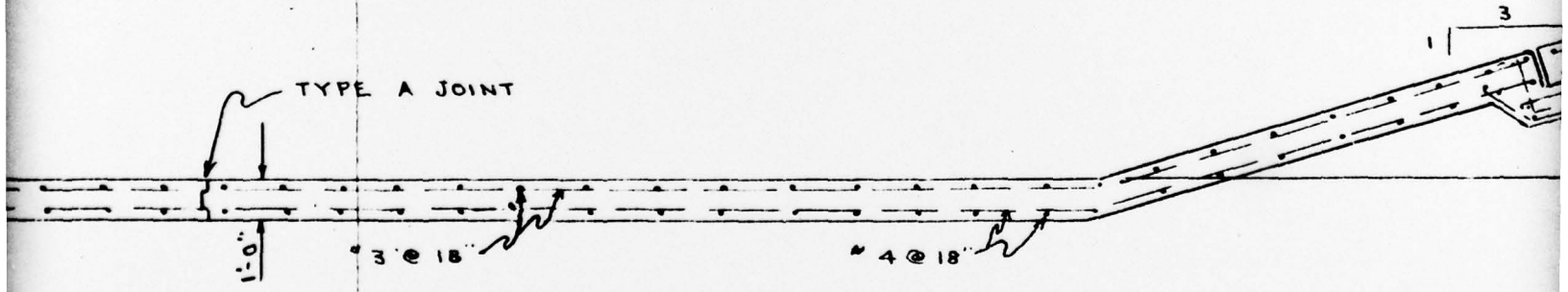


SPILLWAY

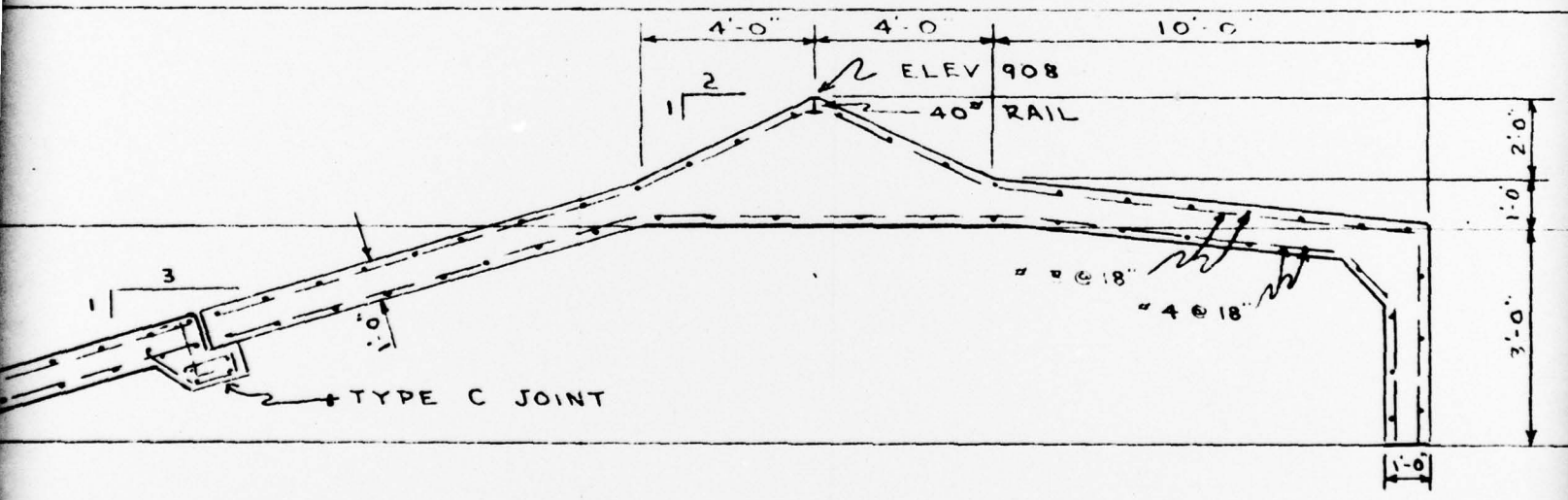
SC

2

50'-0" FOR SECTION C-C



WAY SECTION A-A
SCALE 1/4 = 1'-0"



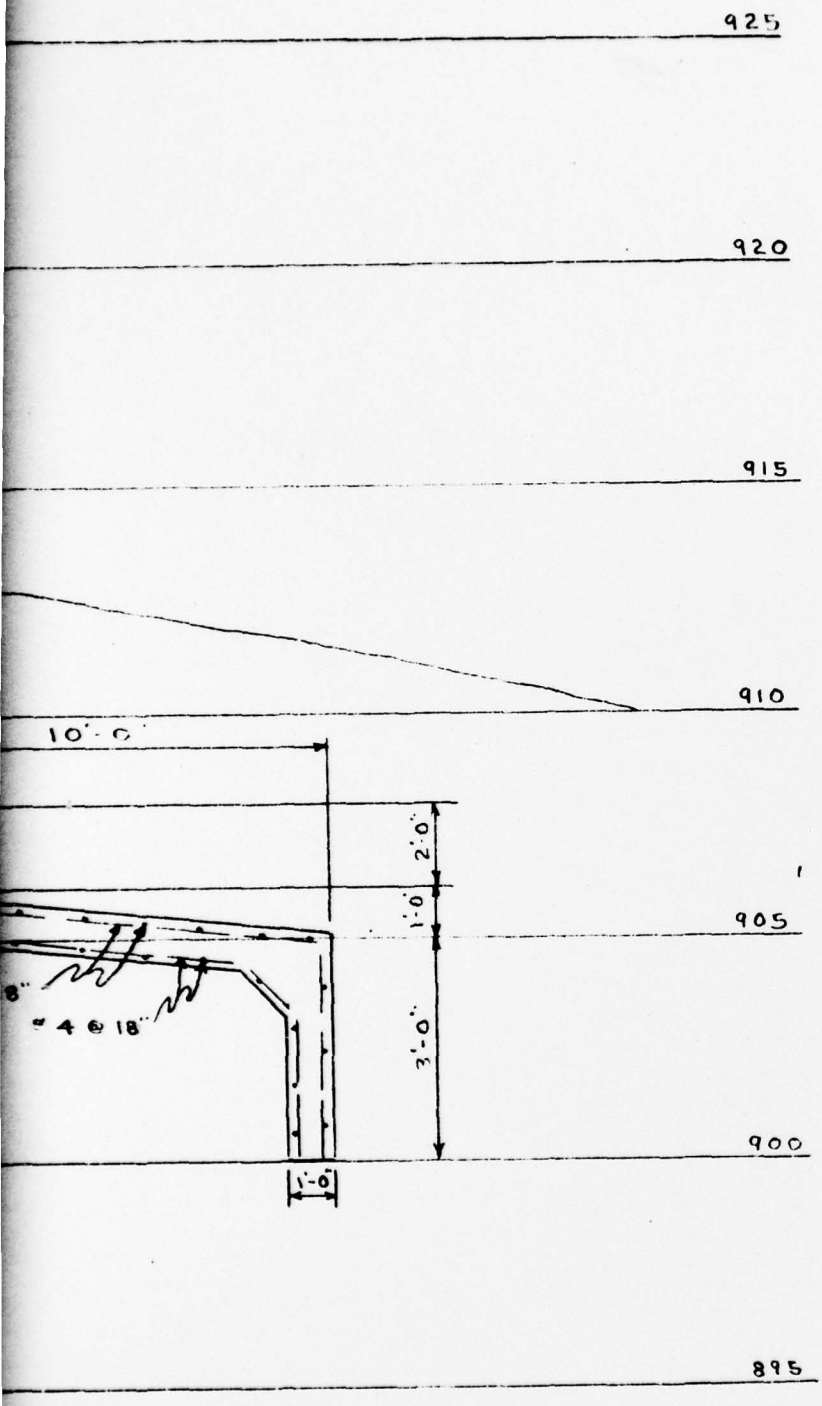


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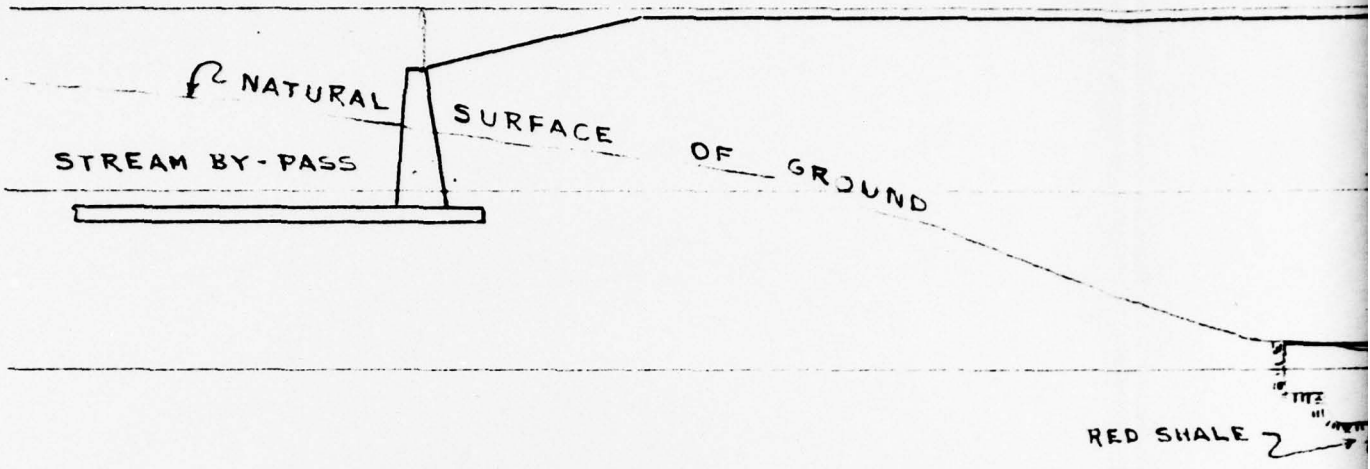
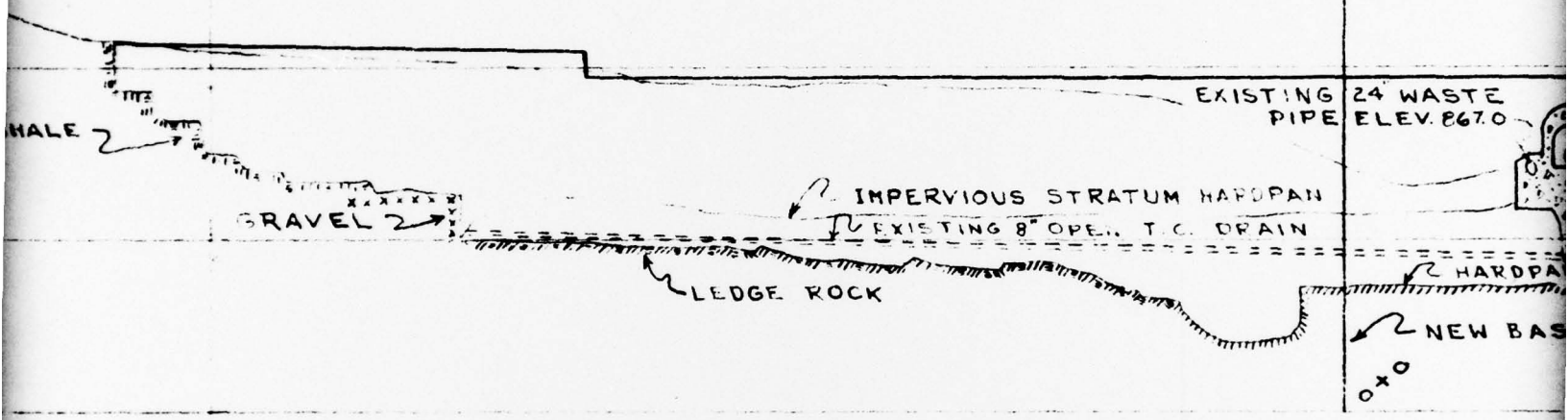
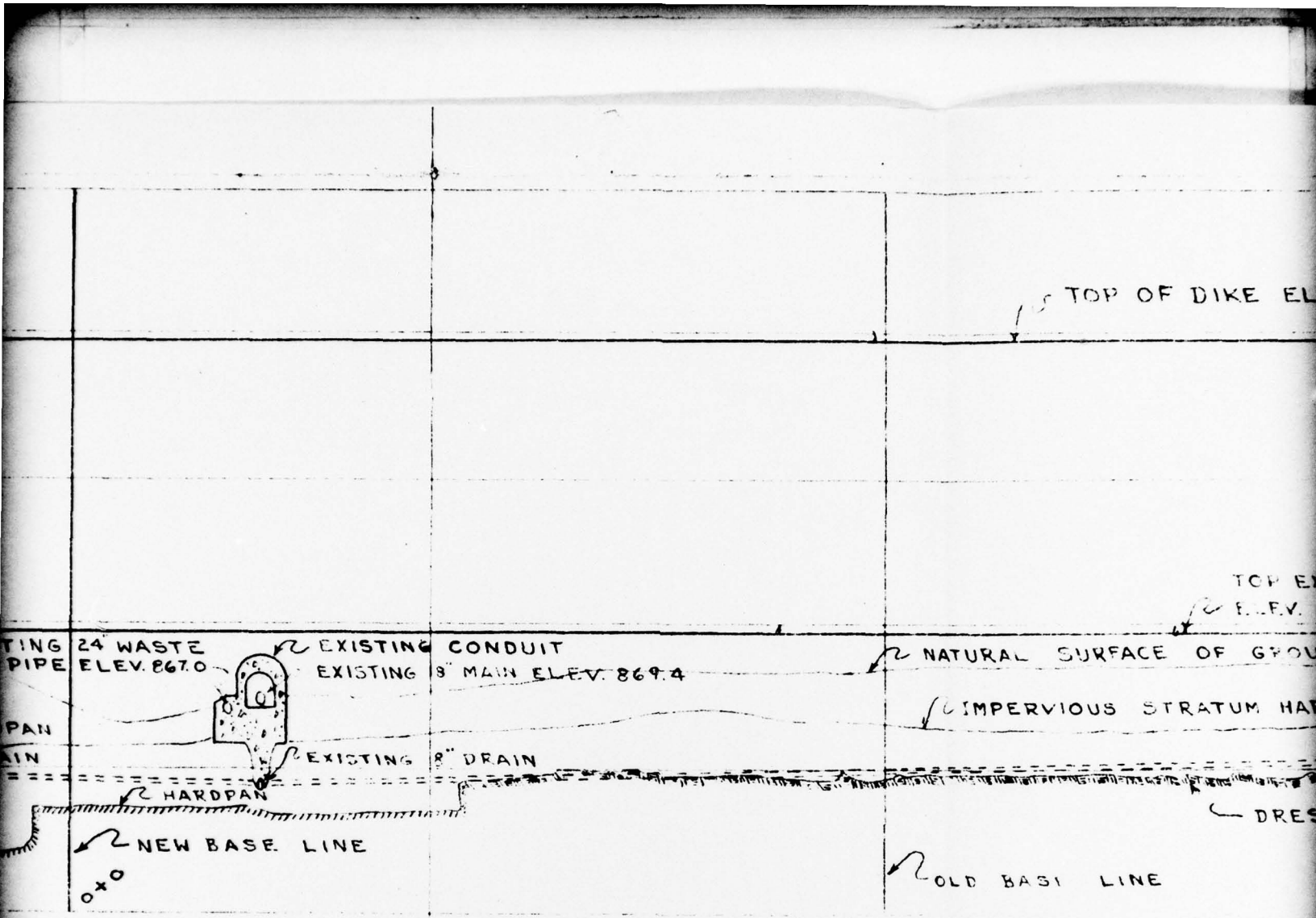
PLATE IX





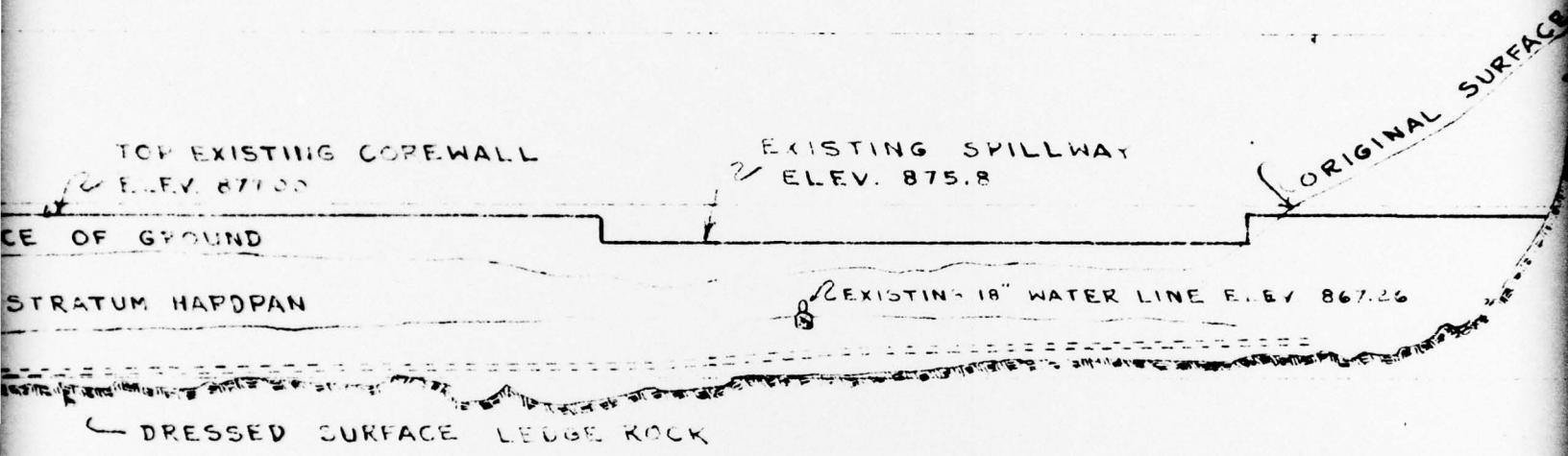
LONGITUDINAL



NGITUDINAL SECTION THRU COREWALL

SCALE 1" = 20'

OF DIKE ELEV 919.00



IE

DRAWN BY R.F.M	
DATE 12-30-55	
APPROVED 1-16-56 BY CITY COUNCIL	
APPROVED BY PENNA DEPT HEALTH	
APPROVED BY PENNA FORESTRY DEPT	
SCALE 1" = 20'	
SHEET 6 OF 10	

EMBANKME

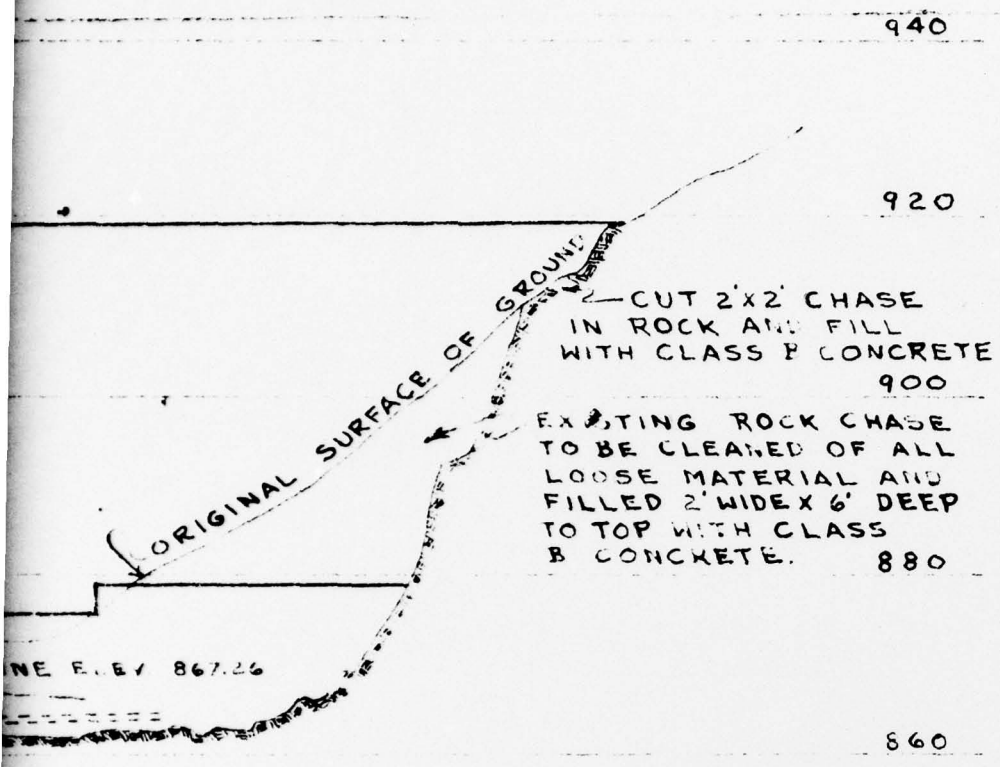
RESERVOIR

LOCK HAVEN

WARREN H OHL -

HILL AND HILL EN

4



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EMBANKMENT SECTIONS

RESERVOIR CONSTRUCTION

LOCK HAVEN CITY AUTHORITY

WARREN H OHL - REGISTERED ENGINEER

HILL AND HILL ENGINEERS CONSULTANTS

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